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MANUAL FOR SURVEY, INVESTIGATION AND PREPARATION OF ROAD PROJECTS

INDIAN ROADS CONGRESS

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1. INTRODUCTION

1.1. Preparation of highway projects involves a chain of activities, such as, field surveys and investigations, selection of alignment, carrying out various designs, preparation of drawings and estimates, etc. To be compatible with technical requirements, consistent with economy, it is essential that every project should be prepared after thorough investigations and collecting all relevant information and evaluating all possible alternatives.

1.2. The extent and quality of investigations have a strong influence on selection of the most cost-effective design, estimation of quantities cost and execution of the job itself. As such, accuracy and completeness of surveys deserves very special attention in project preparation. The objective can be achieved by carrying out the project preparation work either departmentally or with the help of consultants. In any case, it should be ensured that experts having the required knowledge are deployed on the work. Use of modern instruments and survey techniques ensure high degree of accuracy and can speed up the work. Quality Assurance Plan is required to be drawn before the start of field investigations.

1.3. Adequate funds should be earmarked for the work of survey, investigation and project preparation. Estimation of realistic fund and time requirement needed for project preparation will go a long way in making the project preparation a success. It will be found that in the long run, such investment pays more than for itself in the form of well prepared and cost effective projects, orderly schedule of work and timely completion.

1.4. Systematic presentation of project details is no less important. The project document is the very basis of technical, administrative and financial sanction of a project. It is also crucial for accurate execution of work in the field. The project should, therefore, be comprehensive enough for proper appreciation of the proposals as well as easy understanding of the details. This Manual lays down guidelines both for survey and investigations and presentations of the project details.

1.5. The Indian Roads Congress first published this manual in 1977. Since then, considerable experience has been gained by the Highways Departments and Consultants in this field, making it necessary to revise the manual. The work was taken up by the Project Preparation, Project Contract and Management Committee of the Indian Roads Congress. Initial revised draft of the manual was prepared by Dr. L.R. Kadiyali. The Committee appointed a Sub-committee consisting of Sarvashri Devendra Sharma as Chairman, A.K. Mukherjee, P.K. Datta, D.C. De to finalise the revised draft of the manual. The Sub-committee reviewed and modified the initial draft and the revised draft of manual was placed before the Committee in the meetings held on 12-1-1997, 5-1-1998 and 22-4-1998. The Project Preparation, Project Contract and Management Committee (H-8) (personnel given below) approved the draft in its meeting held on 6th July 1998.

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The manual was approved by Highways Specifications and Standards Committee, Executive Committee and Council (held at Jaipur) of Indian Roads Congress in their meetings held on 25-10-1998, 16-7-99 and 6-8-99 respectively.

2. SCOPE

2.1. The manual deals with rural sections of National Highways, State Highways and Major District Roads. It does not deal with Other District Roads and Village Roads, for which a reference may be made to the "IRC:SP:20 Manual on Route Location, Design, Construction and Maintenance of Rural Roads". However, the provisions and guidelines in this manual are expected to be applicable to a large extent to Urban Roads, Expressways and BOT projects also[1]. But for these roads, some additional specific requirements may be there, than those dealt in this document. The manual deals with new construction as well as improvements to existing roads. Special aspects of each have been highlighted wherever necessary. The selection of alignment of any road is generally not governed by the siting of cross-drainage structures except in case of major bridges of length more than 60 m. IRC:SP:54 "Project Preparation Manual for Bridges" lays down guidelines covering the various aspects which are to be detailed in the preparation of a bridge project of length more than 6 m. The survey and investigation for small cross-drainage works with length less than 6 m is covered in IRC:SP:13. For hill roads and road tunnels, reference may also be made to IRC:52 "Recommendations about the Alignment, Survey and Geometric Design of Hill Roads" and IRC:SP:48 "Hill Road Manual".

2.2. In order to ensure that the surveys and investigations, Feasibility Report and Detailed Project Report are complete and no essential detail is missed, a checklist for each of those activities is presented in the ***Appendices - 4, 5 & 6.***

2.3. It should be understood clearly that the extent of operations involved in surveys and investigations including the detailing of the individual aspects, would depend very much on the size and scope of each project and the class of the highway. Depending on needs of the situation, one or more phases of investigations might be curtailed, telescoped or made more extensive than prescribed in the manual.

2.4. The order in which various surveys are discussed in the manual should not be taken to mean that such work must strictly follow the same pattern or sequence. Some of the surveys could easily be initiated in advance and carried out simultaneously overlapping each other. For example, some results of soil and materials survey and study of cross-drainage structures would be needed as an essential input to the Feasibility Report. But more detailed investigations on these aspects may be continued in the detailed engineering phase. It should be upto the Engineer-in-charge to exercise his discretion and adopt a flexible approach. The requirements of the funding agencies or the authority according administrative approval may also result in rescheduling the sequence of work and in redefining the extent of coverage of each work.

3. STAGES IN PROJECT PREPARATION

3.1. Broadly, the stages involved in the preparation and sanction of project are :

1. Pre-feasibility study
2. Feasibility study/preliminary project report preparation
3. Detailed engineering and plan of construction

3.2. In some cases, specially for externally funded and BOT[3] projects, it may be necessary to prepare a pre-feasibility report to enable a funding agency or private financier to appreciate the broad features of the project, the levels of financial involvement and probable returns. This may be done on the basis of reconnaissance survey by collecting information on the present status of the road, deficiency/ distress identification, development potential, environmental impact, traffic data (present and future), approximate estimation of cost and an economic analysis. The economic analysis may involve traffic allocation studies, assessment of resource generation potential, funding pattern and risk. Location of toll plaza sites may also need to be identified[4].

3.3. The Feasibility Study is intended to establish whether the proposal is acceptable in terms of soundness of engineering design and expected benefits from the project for the investments involved. The Feasibility report enables the funding agency to accord approval to the project. This approval is commonly known as Administrative Approval (AA) in the Highway Departments/ Public Works Departments in the country. When international funding is involved, the Feasibility Study forms a basis for an investment decision.

3.4. The Detailed Engineering covers detailed alignment surveys, soil and materials surveys, pavement design studies, drainage studies, environment management plan based on environment impact assessment studies, detailed drawings, estimates and implementation schedules and documents. On the basis of such work, Technical Approval and Financial Sanction (TA and FS) are accorded to the project, enabling it to be executed.

For externally funded and BOT projects, the requirements at various stages are different and may ask for specific informations involving various degree of accuracy of survey and investigations.

3.5. The sequence of survey operations and project preparation may thus, have to be structured to meet the specific needs of the project, its funding option and the requirements of the authority sponsoring it.

3.6. Fig. 3.1. gives a flow chart of the operations involved in highway project preparation.

3.7. **Land Acquisition**

The process of land acquisition needs to be started immediately after finalising the alignment.

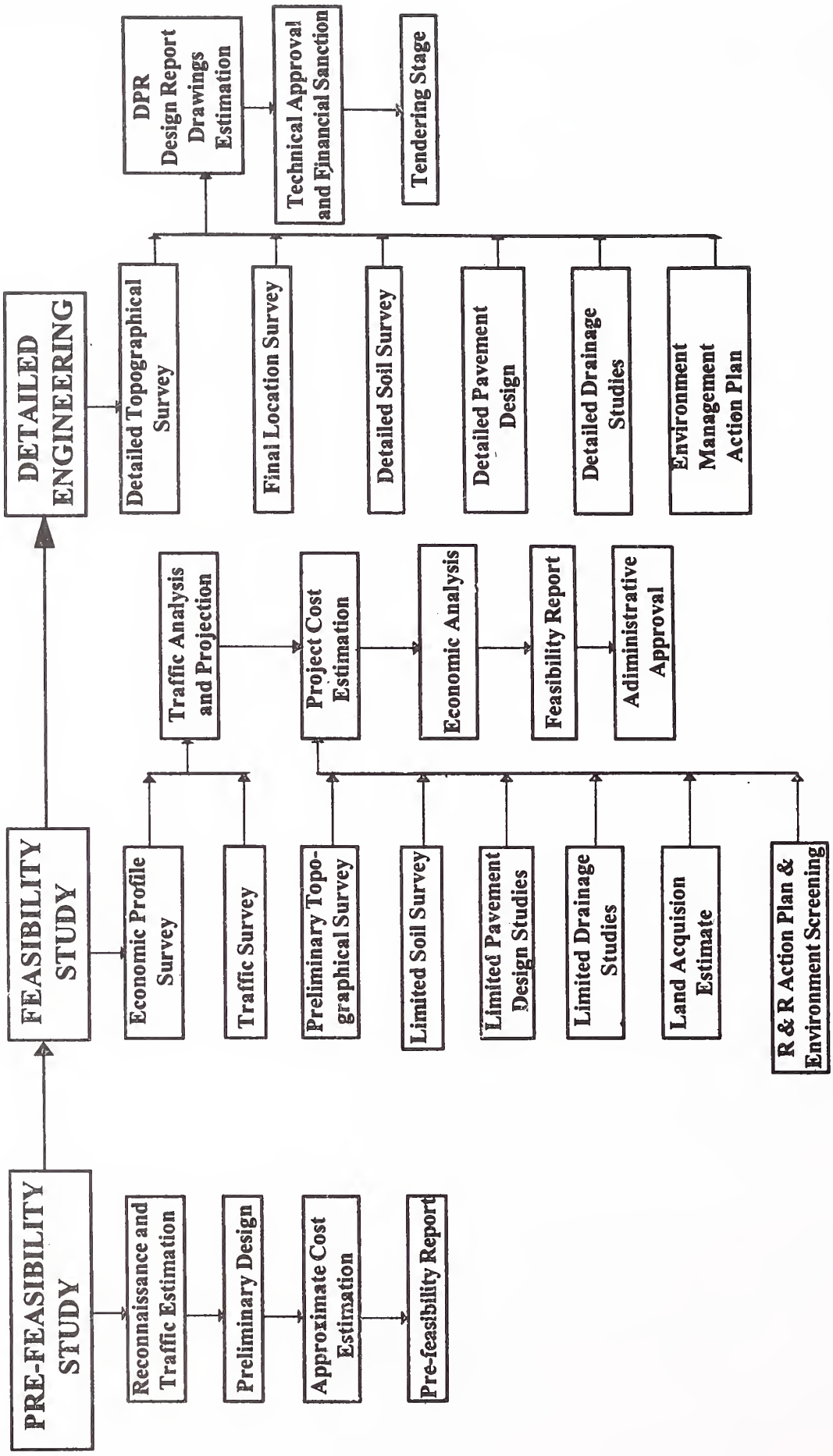


Fig. 3.1. Stages in Project Preparation

Provisions of the appropriate Land Acquisition Act will govern the various steps to be followed in the process of land acquisition. Depending on the quantum of land acquisition, creation of separate land acquisition authority may also be sometimes necessary. Acquisition of Government land, Private Land, Forest Land and land falling under Costal Regulation Zone, etc. will attract different acts/regulations.

The various steps in land acquisition, namely, appointment of exclusive completent authority, if required declaring intention of acquisition, issuing notices and giving hearing to the affected parties, joint measurements, final notices and acquisition of the land, etc. require considerable time and need to be closely monitored to acquire the land within the desired time limit.

Temporary and permanent structures coming in the alignment, trees need to be cut, including those in the forest lands, need special attention for obtaining permission/valuation from the Competent Authority. Similarly, obtaining permission of the Ministry of Forest and Environment for the forest land and the land coming in the coastal regulation zone need to be processed in time.

Identifications and acquisition of land for borrow areas, quarries, etc. also need to be started in advance in case of large projects, such as, national highway project and expressway projects.

4. GUIDING PRINCIPLES OF ROUTE SELECTION AND ALIGNMENT IMPROVEMENT

4.1. The fundamental principle of route selection and alignment improvement is to achieve the least overall cost on transportation, having regard to the costs of initial construction of the highway facility, its maintenance, and road user cost, while at the same time, satisfying the social and environmental requirements. To achieve this objective, it will be necessary to make a detailed investigation before the location is finally decided. Factors that should be kept in view in the process are listed in ***Appendix-1*** and in Fig. 4.1. It should be understood that all these factors may not be applicable to each and every highway project and some of them, even if applicable, may not be feasible in many circumstances. For each case, the Engineer-in-charge has to exercise his own judgement to reach an optimum compromise solution in the light of the fundamental principle of minimum transportation cost enunciated earlier.

4.2. Where the project involves improvements to an existing road, every effort should be directed towards removing the inherent deficiencies with respect to

- Plan and profile
- Sight distance/visibility in horizontal as well as vertical plan
- Carriageway, shoulder and roadway width
- Cross-drainage structures
- Road side drainage provisions as well as area drainage considerations
- Safety features.

Any disregard of these aspects may well lead to unnecessary expenditure, since at a later date the alignment may again have to be improved at considerable extra cost. It is, therefore, imperative that the final centre line of the road with respect to which, the improvements are designed and are to be carried out, is fixed with great care in the light of ultimate geometric requirements and economy. The other important point is removal of structural deficiencies with an eye on future needs with respect to pavement, culverts, road and area drainage requirement, etc.

4.3 Proper location and orientations of cross-drainage structures is an important factor in the selection of the road alignment. Their importance increases with their length and cost. In general for bridges

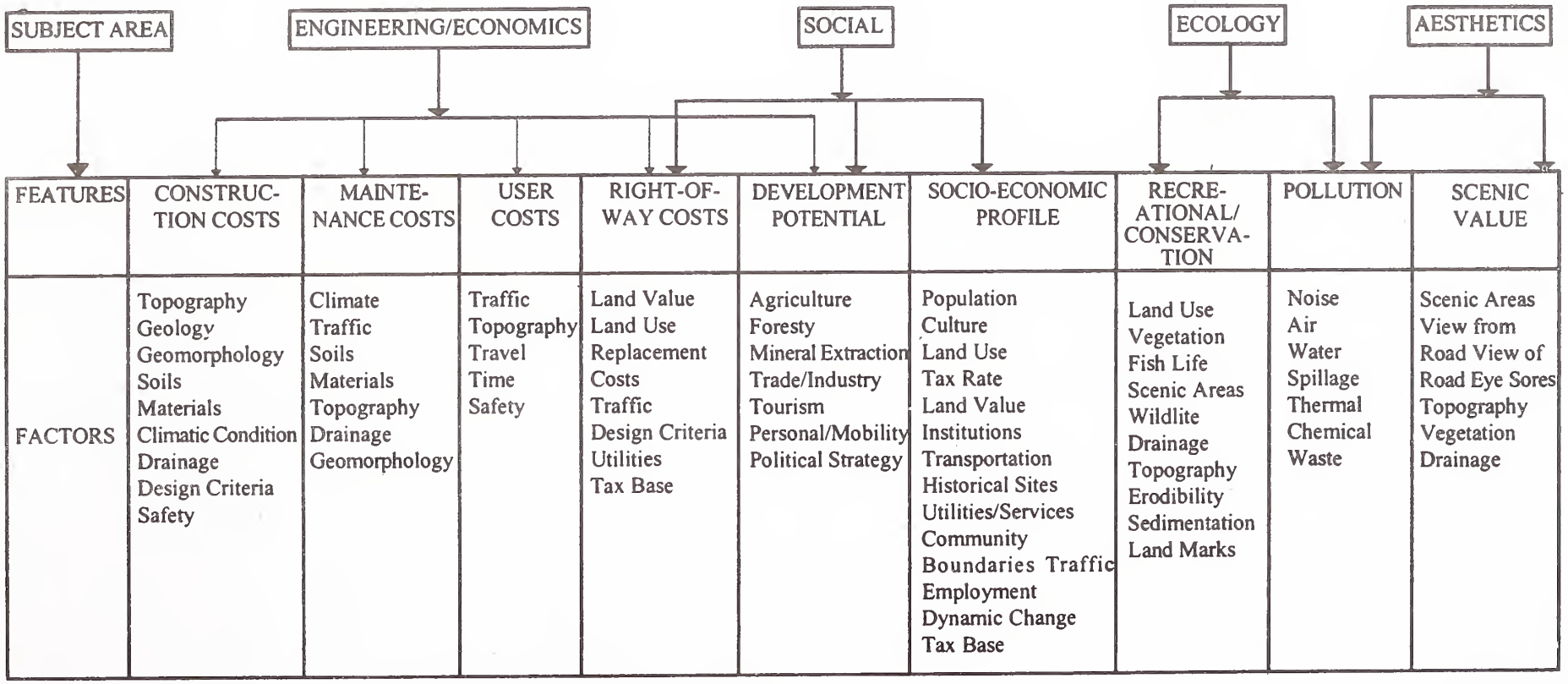


Fig.4.1. Factors Affecting Route Selection & Alignment Improvement

having length between 60 to 300 m, siting of the bridges as well as alignment of the approaches will have equal priority and should be well co-ordinated. For bridges of length more than 300 m, siting for the bridges will be primary guiding factor in route selection.

4.4. Apart from engineering factors, environmental impact of the proposal should be fully kept in view in terms of such aspects as air pollution, damage to life systems, soil erosion, drainage pattern, landscaping, disruption of local communities. etc*.

5. SURVEY OF SOCIO-ECONOMIC PROFILE

5.1. The economy of a region and its transport infrastructure are closely inter-related. The economic justification for a highway project often depends upon the economic activities in the region and potential for their further growth. The growth of traffic on the roads is likely to be closely governed by the inter-relationship between transport demand and certain selected economic indicators. A survey of the economic profile is, thus, an important component in project preparation.

5.2. The economic profile data are generally collected at two levels, *viz.*, (a) Region or State and (b) Project Influence Area. The regional economic profile gives an idea of how the economic growth has taken place in relation to growth of traffic, thus, giving a basis for estimation of future growth of traffic for various scenarios of economic growth. The Project Influence Area is the zone in the near vicinity of the highway project such that investments in the project serve as a catalytic agent towards the speedy development of the area. Such a development generates additional traffic other than the normal.

5.3. The economic profile survey of the region should enable the presentation of an overview of the region's/State's economy, population and transport system over the past years and projected to future years. The data should be collected for the past about ten years. This item is also covered in ***Appendix-6.***

5.4. The socio-economic status of the Road Influence Area should provide a descriptive and quantified profile from available data on population, agricultural production, area under crops, annual industrial and mining production by type of establishment, tourism potential and the inputs and outputs moving by road. Information on major planned development projects (type of establishment and expected annual production) should be collected.

5.5. The historical trend data should be analysed statistically to determine the growth trends and elasticity of traffic with respect to GDP, population, industrial production and agricultural output. The planned rates of growth of those selected indicators in the future should be obtained.

6. TRAFFIC SURVEYS AND ANALYSIS

6.1. General

Information about traffic is indispensable for any highway project since it would form the basis for the design of the pavement, fixing the number of traffic lanes, design of intersections and economic appraisal of the project, etc. Traffic surveys required to be conducted in connection with the preparation of road project are as under:

(a) Classified Traffic Volume Counts

(b) Origin-Destination Surveys

* For assessing environmental impact of highway projects, a reference may be made to IRC publication "Guidelines for Environmental Impact Assessment of Highway Projects", IRC:104-1988.

(c) Speed and delay studies

(d) Traffic Surveys for the Design of Road Junction

(e) Traffic Surveys for Replacing Railway Level Crossings with Over Bridges/Subways

(f) Axle Load Surveys

(g) Accident Records

These are discussed below:

6.2. Classified Traffic Volume Counts

Count of traffic is the basic traffic study required in connection with many types of highway projects. A system of traffic census is in vogue in the country under which 7 day traffic counts are taken once or twice a year. The data from these can be indiciously made use of, if the census points fall on the proposed highway project. Time permitting, it is always desirable to under take fresh traffic surveys. Guidance may be taken from IRC:9 "Traffic Census on Non-Urban Roads." The count stations should be selected such that the results represent the traffic flow in homogeneous sections of the highway. A seven day count will then give the Average Daily Traffic (ADT). This value may be converted to Annual Average Daily Traffic (AADT) applying seasonal considerations and using conversion factors from any continuous traffic count in the region.

When traffic census data from existing count stations are compiled, it may be found useful to collect past data (preferably about 10 years) so as to establish meaningful past growth trends for each vehicle class. A typical proforma 1 given in this Chapter may be used.

6.3. Origin-Destination (O-D) Surveys

6.3.1. When a new road is being planned, or extensive improvements are to be carried out to an existing road, or a bypass is under consideration, the amount of traffic likely to use it cannot be ascertained from a simple census and it may become necessary to collect information about the origin and destination of traffic passing through the area in which the road is situated. The origin and destination data should be comprehensive enough to cover all roads likely to be affected by the proposed scheme. The points at which the data is collected should be carefully chosen on the road network such that it should be possible to derive the volume of traffic likely to use the facility under consideration.

6.3.2. The survey should normally be conducted for three consecutive days, on sample basis if possible during a representative week in the year and must encompass the weekly market day and one working day. For exceptional cases, in heavy density corridors and where the daily variation in the traffic is not much, at least one day's survey may be conducted on a normal working day. Care shall be taken during interpretation of the data keeping in mind the seasonal variation of traffic.

6.3.3. There are several methods available for conducting an O-D survey. Information on them is contained in IRC:102 "Traffic Studies for Planning Bypasses Around Towns". Generally, the "Roadside Interview Method" is well-suited for roads in rural areas and can be conveniently adopted. This consists basically of interviewing drivers of vehicles at suitably located points with reference to the type of road scheme in consideration. At these stations, the number as well as the type of all vehicle passing the station is recorded. However, only a percentage of the drivers at random need to be stopped and interviewed for origin, destination and other travel particulars, like, commodity carried. The sampling should be systematic. Generally, 15 to 20 per cent of the vehicles may be covered in the peak periods and 25 to 30 per cent in the normal periods.

6.3.4. The sample should be upscaled to ADT and preferably hourly based classified vehicle type. The location of origin and destination zones will be determined in relation to each individual station and the possibility of traffic diversion to the project road from other road routes including bypasses. In principle, the zoning should bisect areas where competing roads pass and the zonal configuration shall be adequate on either side of the O-D station; thereafter, districts will serve as zones within the State. Zoning outside the State will relate to individual or groups of States in accordance with the distance from the O-D station. For coding purposes, code lists or code maps (to be shown to motorists) will be prepared giving zone number and towns within that zone. The updated (ADT) numbers shall then be presented by trip matrix. Information on weight for trucks should, following up scaling to ADT, be summed up by commodity type and the results tabulated, giving total weight and average weight per truck for the various commodity types. Sample sizes for each vehicle type should also be indicated. A sample of Zonal Division is indicated in Fig. 1.

Following processing of the O-D results, traffic is assigned from the trip matrix's elements to the project road's homogeneous sections, provided the route including the project road in its improved condition is the most desirable of the alternative routes available in terms of least vehicles operating costs.

6.4. Speed and Delay Studies

Highway improvements result in speeding up traffic and reducing congestion. Speed and delay studies on the existing facility provide the basis for estimating the causative problems and benefits of the improved facility. For this purpose typical proformae 2(a) and (b) given in this chapter may be used.

The study is conveniently conducted by the "Moving Observer" method. By this method a test vehicle is run along with the traffic stream, at approximately the perceptible average speed of the traffic stream. A separate run is needed for each direction. The average of around six runs ensures accuracy of results. By noting down the travel time, including actual running time and stopped delays, the vehicles counted in the opposite direction and those overtaken/overtaking, it is possible to calculate the volume, speed and delay. For further information, IRC:102 "Traffic Studies for Planning Bypasses Round Towns" may be consulted. Proformae 3(a) to (d) given in this Chapter may be found useful for this survey.

6.5. Traffic Surveys for the Design of Road Junctions

6.5.1. Road junction design requires information on directional movement of traffic in the peak hour. For this purpose, it would be sufficient to have counts for 2 hours each in the morning and evening peak periods unless there exist extended peak hours.

6.5.2. For simple 'T' or 4-way junction, the survey could be conducted by stationing enumerators on each arm of the junction to note the number of vehicles entering through the arm and the direction of their exit. At multi-legged junction or rotaries, quick judgement about the exit direction or vehicles may not be possible. In such cases, a licence plate survey may have to be conducted. This consists of noting the registration numbers (generally only the last three digits) of a sample of vehicles entering the intersection. Simultaneously, on each exit, the registration numbers of vehicles leaving the junction are noted. The two sets of numbers are then matched in the office to determine the directional movements. For recording traffic movement at a junction Table 3.1. Interesection Design Data given in IRC:SP:41 Guidelines for the design of At-Grade interesections in rural and urban areas needs to be used.

6.5.3. Usually, it is not necessary to conduct traffic surveys on junctions where traffic on the minor cross road is less than about 100 vehicles per day.

6.5.4. Special pedestrian survey needs to be conducted when the alignment passes by such

locations, (e.g., school, well, etc. on one side of alignment and the village on the other side), to decide the provision of appropriate crossing, such as, subway.

6.6. Traffic Surveys for Replacing Railway Level Crossings with Over Bridges/Subways

6.6.1. Present criteria of replacing railway level crossings with over bridges/underpasses are based on the product of gate closures and fast traffic per day. For this purpose, counts should be taken in a week spread over three consecutive days and 24 hours each day if such information is not already available. The number and duration of gate closures should be ascertained from the Railway Authorities and also counted at site by conducting a 24 hours survey.

6.6.2. Information should also be obtained on the angle of crossing of the roadway and the railway. In case the road alignment has curves near the railway crossing, to make it a perpendicular crossing, an index plan including these curves and the straight alignment beyond, should also be included to study the feasibility of improving the road alignment as part of the project for replacing the level crossing.

6.7. Axle Load Survey

Axle load survey is needed to generate data for pavement design. Portable weigh bridges are very useful for this purpose.

This survey shall be carried out along with classified volume count survey. Number of days of survey will depend on project location, the type of project and the intensity and expected variation in traffic. This survey duration may vary between 24 hours and 3 days, but should be carried out at least for one day at the traffic count stations on a random basis for commercial vehicles. Buses may be omitted as their weight can be easily calculated and they do not result in excessive overloads.

The period of conducting the survey should also be judiciously selected keeping in view the movement of commodity/destination oriented dedicated type of commercial vehicles.

While finalising the design Equivalent Standard Axle load, the following should be considered.

(i) Past axle load spectrum in the region as well as on the road to the extent available

(ii) Annual variation in commercial vehicles

(iii) Optimistic and pessimistic considerations of future generation of traffic

(iv) Generation of changing VDF factor during the project period

A typical proforma 4 given in this chapter may be found useful for this survey.

6.8. Accident Records

If accident records are maintained in a methodical manner, they form a good basis for designing the improvements at accident-prone locations on existing roads. Such records, if available, should invariably be consulted before deciding the improvement measures.

6.9. Traffic Projection

6.9.1. Traffic counts and O-D surveys would provide information about present traffic on the road (in the case of existing roads), or the possible diverted traffic (in the case of new construction, such as, bypasses). For design purpose, however, it is necessary that classified traffic should be predicted for the future horizon year for which the facility is to be designed.

6.9.2. Period of projection depends on the type of the project, importance of the road, availability of finances and other related factors. For major trunk routes, the desirable and minimum forecast periods are 20 and 10 years, (excluding the period of construction) though occasionally an even shorter period could be adopted depending on the policies of stage construction. In the case of lower category roads, the desirable period of projection is 10 years but it should not be less than 5 years.

6.9.3. Traffic growth should be assessed in the first instance on the basis of observed trend of traffic in the recent years and other economic indicators using the technique given in ***Appendix-2.*** In this connection the Guidelines for Traffic Prediction on Rural Highways, IRC:108 may be referred to. If reliable information is not available, as a broad guide, a compound growth rate of 7.5 per cent per annum could be adopted for this purpose. Because of the many uncertainties surrounding the possible shape of future population, incomes, production, goods generation, etc., it is necessary that estimates of traffic based purely on past rates of growth should be used with caution.

6.9.4. Forecast of traffic based on past trends should also be modified for 'generated' traffic that may be using the highway facility after it is constructed. Generated traffic is quite distinct from the diverted traffic and represents journeys induced by reduced journey times and higher level of travel comfort which would not otherwise have been made. It is not necessary to allow for generated traffic on small schemes, but this may be called for on comparatively larger projects. Estimation of generated traffic should be attempted after consulting standard literature on this subject.

7. RECONNAISSANCE SURVEY

7.1. Purpose

7.1.1. The main objective of reconnaissance survey is to examine the general character of the area for the purpose of determining the most feasible route, or routes, for further more detailed investigations. Data collected should be adequate to examine the feasibility of all the different routes in question, as also to furnish the Engineer-in-charge with approximate estimates of quantities and costs, so as to enable him to decide on the most suitable alternative or alternatives. The survey should also help in determining any deviations necessary in the basic geometric standards to be adopted for the highway facility.

7.2. Survey Method

7.2.1. The reconnaissance survey may be conducted in the following sequence

(a) Study of topographical survey sheets, agricultural, soil, geological and meteorological maps, and aerial photographs, if available

(b) Aerial reconnaissance (where necessary and feasible),

(c) Ground reconnaissance (including another round of aerial reconnaissance for inaccessible and difficult stretches, where called for)

7.3. Study of Survey Sheets, Maps, etc.

7.3.1. Reconnaissance begins with a study of all the available maps. The types of useful map informations which are currently available in the country are as below:

(a) Survey of India (SOI) Maps.

(i) The most useful maps are the topographical sheets available in the scale of 1:25,000, 1:50,000 and 1:250,000.

Proforma 1

CLASSIFIED TRAFFIC VOLUME COUNT SURVEY

Road Name	:		Road No.	:	
Section From	:	To	Station No.	:	ADDL. INFORMATION :
Location Km.	:		Date & Day	:	WEATHER :
Direction Towards	:		Hour	:	

	FAST MOVING VEHICLES											SLOW MOVING VEHICLES				
TIME	Two Wheeler	Three Wheeler/ Auto Rickshaw	Car/Jeep/ Van/Taxi	BUS		LCV	TRUCK			Agri. Tractor		Cycle	Cycle Rickshaw	Animal Drawn		Others (Pl. Specify) Drawn
				Mini	Full		2-Axle	Multi-Axle	Artic/ Semi Artic	With Trailer	Without Trailer			Bullock Cart	Horse	
00--15																
15-30																
30-45																
45-60																
TOTAL																

Name &

Signature of Enumerators: _____

Name &

Signature of Supervisor: _____

Proforma 2(a)

ORIGIN & DESTINATION (O-D) SURVEY (FREIGHT TRAFFIC)	Sheet No.

Name of Road :
Road No. :
Location at Km
Weather :

Towards :
Date :
Day :
Time :

Sl. No. → / Particulars ↓							
VEHICLES PARTICULARS	Registration No.						
	Type of Vehicle & Axle Configuration						
	Make & Model						
	RLW/ULW						
COMMODITY/ O-D PARTICULARS	Commodity Type						
	Quantity (Tonnes/Litre)						
	Origin (Name of Place & District/State/Country)						
	Destination (Name of Place & District/State/Country)						
VEHICLE UTILISATION	Trip Length (Km)						
	Number of Trips						
	Average Km Driven/Day No. of Hours per Day						
	No. of Working Days Per Month						
ROUTE PARTICULARS	Adopted						
	Preference for Proposed Superior Road						

Name & Signature of Emunerators:_____

Name & Signature of Supervisor _____

Proforma 2(b)

ORIGIN & DESTINATION (O-D) SURVEY (CAR/BUS)	Sheet No.

Name of Road :
Road No. :
Location at Km :
Weather :

Towards :
Date :
Day :
Time :

Sl. No. → / Particulars ↓							
VEHICLES PARTICULARS	Registration No.						
	Type of Vehicle No. of Passengers						
	Origin (Name of Place & District/State/Country)						
	Destination (Name of Place & District/State/Country)						
VEHICLES UTILISATION	Trip Length (Km)						
	Number of Trips						
	Average Km Driven/Day No. of Hours per Day						
	No. of Working Days Per Month						
ROUTE PARTICULARS	Adopted						
	Preference for Proposed Superior Road						

Name &
Signature of Emunerators:_____

Name &
Signature of Supervisor _____

Proforma 3 (a)

Name of Project

SPEED AND DELAY STUDY FORM NO.-1

FORM FOR RECORDING THE TIME AT VARIOUS CONTROL POINTS

Name of Road_____ From_____ To_____

From Km_____ To Km_____ No. of Trip:_____

Date: _____

Time_____

Sl. No.	Distance		Control Points	First Stop Watch		Second Stop Watch		Cause of Delay
				Journey Time		Delay Time		
	Km.	M.		Min.	Sec.	Min.	Sec.	

Name and Signature_____ Name and Signature_____

of Enumerators _____ of Supervisors _____

Name of Project _____

SPEED AND DELAY STUDY FORM NO.-2

FORM FOR NO. OF VEHICLES **OVERTAKING** THE TEST VEHICLE

Name of Road : _____ From _____ To _____

From Km _____ To Km _____ No. of Trip: _____

Date & Time _____

Fast Moving Vehicles							
Passenger Vehicles					Goods Vehicles		
Car/Jeep/Auto		Two-wheeler	Mini Bus	Bus	Tempo/LCV	Trucks	
New	Old					2-axle	Multi-axle

Name and Signature of Enumerators: _____

Name and Signature of Supervisors _____

Name of Project _____

SPEED AND DELAY STUDY FORM NO.-3

FORM FOR NO. OF VEHICLES **OVERTAKEN** BY THE TEST VEHICLE

Name of Road : _____ From _____ To _____

From Km _____ To Km _____ No. of Trip: _____

Date & Time : _____

Fast Moving Vehicles						
Passenger Vehicles				Goods Vehicles		
Car/Jeep/Auto	Two-wheeler	Mini Bus	Bus	Tempo/LCV	Trucks	
New Old					2-axle	Multi-axle

Name and Signature of Enumerators: _____

Name and Signature of Supervisors _____

Name of Project _____

SPEED AND DELAY STUDY FORM NO.-4

FORM FOR NO. OF VEHICLES **TRAVELLING IN THE OPPOSITE DIRECTION**

Name of Road : _____ From _____ To _____

From Km _____ To Km _____ No. of Trip: _____

Date & Time : _____

Fast Moving Vehicles							
Passenger Vehicles					Goods Vehicles		
Car/Jeep/Auto		Two-wheeler	Mini Bus	Bus	Tempo/LCV	Trucks	
New	Old					2-axle	Multi-axle

Name and Signature of Enumerators: _____

Name and Signature of Supervisors _____

Name of Project _____

AXLE LOAD SURVEY

Section:
Location:
Direction :

Date & Time

Weather :

Time	Vehicle Type	Origin	Destination	Commodity Type	Axle Load (Tonnes)						Remarks
					1st Axle	2nd Axle	3rd Axle	4th Axle	5th Axle	6th Axle	

Recorded by :

Checked by :

Name and Signature of Enumerators : _____

Name and Signature of Supervisors _____

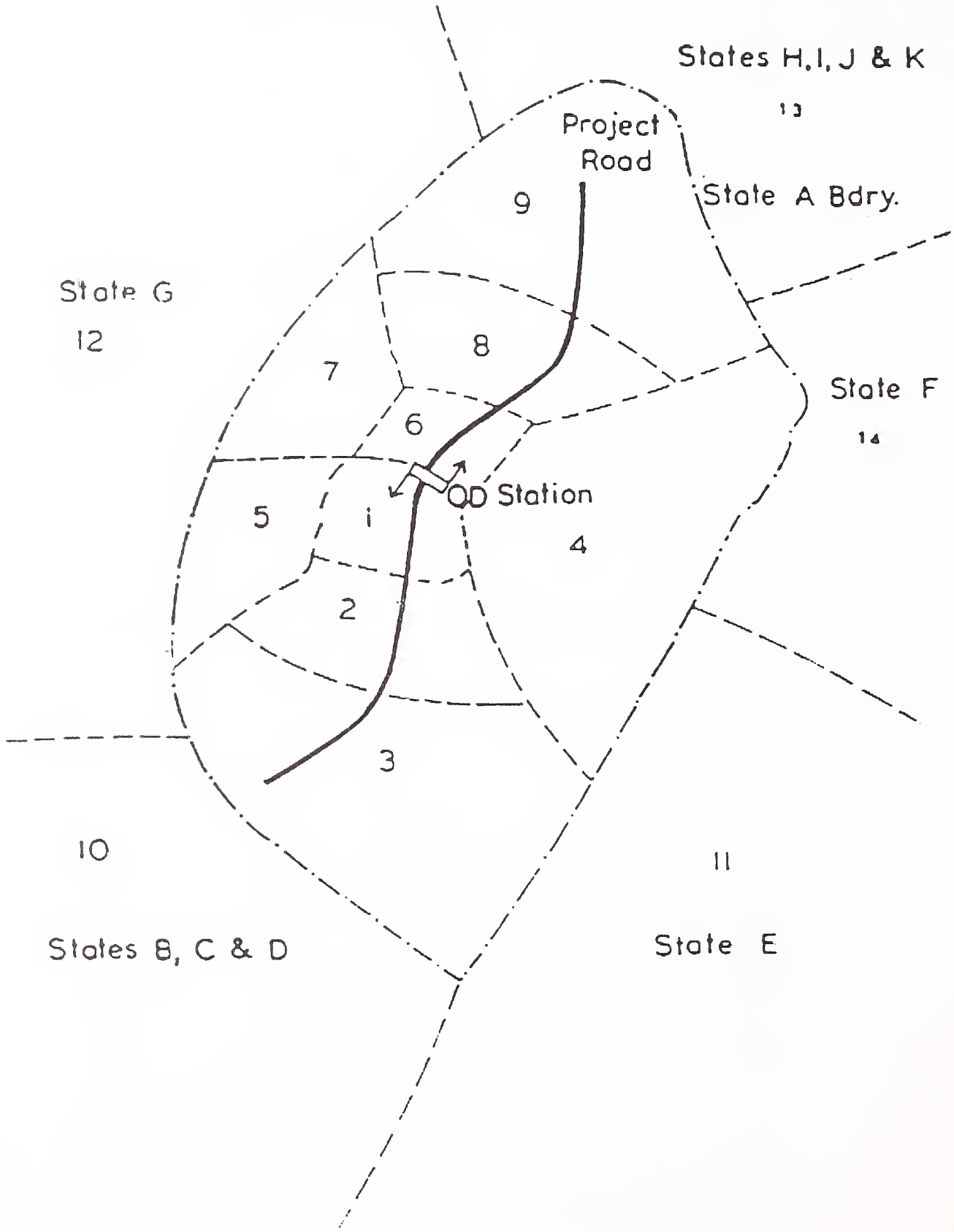


Fig. 1. Zonal Division (Sample)

Maps coverage on 1:50,000 and 1:250,000 scale are available for the whole of India but map coverage with the preferable scale of 1:25,000 is at present, available only for about 30 per cent of the country.

(ii) State maps on scale 1:1,000,000.

These are useful as index maps or to indicate an overview of the project location and are available for most of the States.

(iii) Plastic Relief Maps on scale 1:15,000,000.

One may be lucky to have these maps for certain regions. For very difficult areas highway location planning may be very much helped if these three dimensional maps delineating ridges, valleys, peaks, etc. with contour information are available.

(b) Apart from the above-mentioned SOI maps there are special purpose maps, like, Forest Survey of India, Vegetation Maps on scale 1:25,000,000 showing incidence of orchards, reserve forests, clusters of social forestry areas, etc. which may be helpful in special cases in selection of alignment.

Also, maps prepared by National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) indicating information on Soil, Wasteland, etc. and Geological Survey of India Maps (on scale 1:250,000 or smaller) with information on geology, geomorphology and changes in drainage, river courses, etc. are available for many areas.

These maps may also be fruitfully used when considered necessary.

7.3.2. After study of the topographical features on the maps, a number of alignments feasible in a general way are selected keeping in view the following points :

(i) The alignment should take into account all the control points and should be the shortest and most economical compatible with the requirements of gradient and curvature.

(ii) Shape of the alignments.

(iii) Avoidance, as far as possible, of marshy ground, steep terrain, unstable hill features and areas subject to severe climatic conditions, flooding and inundation.

(iv) Need of connecting important villages and towns.

(v) Bridging cross-drainage and drainage problems. (Guiding principle stated in para 4.2 shall be kept in view).

(vi) Need to preserve environment and maintain ecological balance.

7.3.3. If photographs of the area are not available, but their need is considered imperative, aerial photography may be arranged for further study in the interest of overall economy.

The present status of Aerial Photography (AP) in India is that AP on scale 1:50,000 is available for the whole of India. Depending on their quality the negatives of these photographs, when necessary, can be enlarged easily by about five times without losing clarity and thus obtain AP enlargements on scale of 1:5,000 to 1:20,000.

These enlargements are quite adequate for the study of:

(i) Geology, geomorphology and groundwater prospecting and

(ii) Environmental factors, e.g., vegetation, soil condition, land use etc.

If stereoscopic techniques are applied, aerial photographs can yield quantitative data showing the

terrain in three dimension and if studied by a skilled photo-interpreter, can give significant soil and sub-soil information.

7.3.4. **Photogrammetry support to highway engineering:** Photogrammetry technology is also useful to the highway engineer in many ways. Large scale maps on scales at 1:2,000 to 1:25,000 can be very precisely produced through photogrammetric process. The contouring can also be produced, the common interval depending on the height of the camera. Very minute and precise measurements amounting to sub-metre accuracy can be obtained. In other words, profile (with height values) and cross-sections across highway centre-line can be extracted from optical model.

7.3.5. **Satellite remote sensing:** This technique is used with the help of satellites. At present, it gives a resolution of the order of 6 metres. Photographic products of imagery are available from National Remote Sensing Agency, Hyderabad on scales of 1:12,500, 1:25,000 and 1:50,000. Digital products are also available in floppy cartridge and tapes.

The cartridge/tape can be digitally processed in the computer and the image on the monitor can be interpreted with the possibility of enhancement of quality through manipulation of image processing software.

Major advantages of satellite imagery is its repeatability as orbiting satellites visit the same spot on earth every few weeks. Thus, the latest information regarding the physical features (like, the extent of a town or urban area, etc.) can be obtained to update on available map.The information on natural resources namely, geology, geomorphology, land use, soil status (waterlogging, erosion, etc.), drainage, forest extent, etc. as available may be most useful input for the planners of highway alignment.

7.3.6. **Small format aerial photography (SFAP):** In case of large projects with mapping as one of the main objectives conventional aerial photography in traditional format (23 cm x 23 cm) may also be useful. There are at least three known agencies in India for such aerial photography, namely, the National Remote Sensing Agency (NRSA), Hyderabad, Air Survey Company, Calcutta and the Indian Air Force.

All aerial photography work requires clearance from the Ministry of Defence.

The major advantages of SFAP are:

- Very large scale true colour photo enlargements can be done in scales upto 1:1,000 to 1:2,000 (upto scales of 1:10,000). Acquisition plans along side highways can be suitably made in scale of 1:4,000.
- Monitoring of urban areas, villages and environment along the corridor are possible at comparatively lower cost than ground surveys.

7.4. **Aerial Reconnaissance**

7.4.1. An aerial reconnaissance will provide a bird's eyeview of the alignments under consideration along with the surrounding area. It will help to identify factors which call for rejection or modification of any of the alignment. Final decision about the alignments to be studied in detail on the ground could be taken on the basis of the aerial reconnaissance.

7.5. **Ground Reconnaissance**

7.5.1. The various alternative routes located as a result of the map study are further examined in the field by ground reconnaissance. As such, this part of the survey is an important link in the chain of activities leading to selection of the final route.

7.5.2. General reconnaissance consists of general examination of the ground walking or riding

along the probable route and collecting all available information necessary for evaluating the same. In the case of hill sections, it may some time be advantageous to start the reconnaissance from the obligatory point situated close to the top. If an area is inaccessible for the purposes of ground reconnaissance, recourse may be had to aerial reconnaissance to clear the doubts.

7.5.3. While carrying out ground reconnaissance, it is advisable to leave reference pegs to facilitate further survey operations.

7.5.4. Instruments generally used during ground reconnaissance include compass, Abney level/ Alti-meter, Pedometer, Aneroid barometer, Clinometer, Ghat tracer, etc. Walkie-talkie sets, mobile phones and pagers are useful for communication, particularly in difficult terrain. Use of the instruments mentioned above to obtain ground slopes, maximum gradients, elevation of critical summits or stream crossings, and location of obligatory points, serve as a check on the maps being used.

In difficult hilly and forest terrain assistance of new technology, like, Global Positioning System (GPS) or Differential GPS (DGPS) may also be taken where the magnitude and importance of the work justify their provision. GPS is a comparatively new technology which utilises the satellites orbiting around the earth. A minimum of four satellites are needed to indicate the co-ordinates (X, Y, Z) on the ground at any time of day and night. The observations are made to an accuracy of nearly a few metres or so. For more precise work with accuracy of a few centimetres, two geo-receivers are used and this mode of using two GPS is known as differential GPS (DGPS).

7.5.5. Points on which data may be collected during ground reconnaissance are listed in ***Appendix-3.***

7.6. Reconnaissance Report

Based on the information collected during the reconnaissance survey, a report should be prepared. The report should include all relevant information collected during the survey, a plan to the scale of 1:50,000 or larger as available showing the alternative alignments studied alongwith their general profile and rough cost estimates. It should discuss the merits and demerits of the different alternatives to help the selection of one or more alignments for detailed survey and investigation.

8. PRELIMINARY SURVEY

8.1. Purpose

8.1.1. The preliminary survey is a relatively large scale instrument survey conducted for the purpose of collecting all the physical information which affects the proposed location of a new highway or improvements to an existing highway. In the case of new roads, it consists of running an accurate traverse line along the route previously selected on the basis of the reconnaissance survey. In the case of existing roads where only improvements are proposed, the survey line is run along the existing alignment. During this phase of the survey, topographic features and other features, like, houses, monuments, places of worship, cremation or burial grounds, utility lines, existing road and railway lines, stream, river, canal crossings, cross-drainage structures, etc. are tied to the traverse line. Longitudinal-sections and cross-sections, are taken and bench marks established. The data collected at this stage will form the basis for the determination of the final centre line of the road. For this reason, it is essential that every precaution should be taken to maintain a high degree of accuracy.

8.1.2. Besides the above, general information which may be useful in fixing design features within close limits is collected during this phase. The information may concern traffic, soil, construction materials,

drainage, etc. and may be collected from existing records as through intelligent inspection/simple measurements. **Detailed investigations dealt with in section 10 through 16 are not envisaged at this stage.** It may be found convenient to divide the road into homogeneous sections from traffic consideration and prepare a typical estimate for one km stretch as representative of each homogeneous section. With the data collected, it should be possible to prepare rough cost estimates within reasonably close limits for obtaining administrative approval, if not already accorded and for planning further detailed survey and investigations. In particular, information may be collected regarding :

(i) The highest sub-soil and flood water levels, the variation between the maximum and minimum, and the nature and extent of inundation, if any, gathered from local enquires or other records. These should be correlated to data about the maximum and minimum rainfall and its duration and spacing, etc. by appropriate hydrological analysis.

(ii) The character of embankment foundations including the presence of any unstable strata likes micaceous schists, poor drainage or marshy areas; etc. This is particularly necessary in areas having deep cuts to achieve the grade.

(iii) Any particular construction problem of the area, like, sub-terranean flow, high level water storage resulting in steep hydraulic gradient across the alignment canal crossings and their closure periods. Information regarding earlier failures in the area of slides or settlements of slopes, embankments and foundation, together with causes thereto may also be gathered from records and enquiry where feasible.

(iv) In cut sections, the nature of rock i.e., hard, soft etc. should be determined by trial pits or boreholes. This is essential to make realistic cost estimates.

8.2. Survey Procedure

8.2.1. The preliminary survey starts with running of a traverse along the selected route, adhering as far as possible to the probable final centre line of the road. In difficult situations, a secondary traverse connected to the primary one at either end may also be run. In hilly areas, a trace cut 1.0 to 1.2 m wide, if required may be made during the preliminary survey. For details in this regard, reference may be made to IRC:52 "Recommendations About the Alignment Survey and Geometric Design of Hill Roads".

8.2.2. The traverse consists of a series of straight lines with their lengths and intermediate angles measured very carefully. In difficult terrain, the alignment may have to be negotiated through a series of short chords, preferably, the traverse should be done with a theodolite with Electronic Distance Measurement (EDM) and all angles measured with double reversal method. Global Positioning System (GPS) is also very useful and appropriate for preliminary survey. The GPS will give locations in co-ordinates all the necessary points on the traverse. GPS is very fast reasonably accurate for preliminary system and computer friendly for data transfer. Control pillars in cement concrete should be fixed at suitable interval (ranging from 500 m to 2 kms) to have control on accuracy. It also helps in repeating the survey, if required, within the control pillars.

8.2.3. Distances along the traverse line should be measured with EDM or total station. An accuracy of at least 1 in 10000 should be aimed at in all distance measurement.

8.2.4. No hard and fast rule can be laid down as regards distance between two consecutive transit stations. In practice, the interval will be dictated by directional changes in the alignment, terrain conditions and visibility. The transit stations should be marked by means of stakes and numbered in sequence. These should be protected and preserved till the final location survey.

8.2.5. Physical features, such as, buildings, monuments, burial grounds, cremation grounds, places

of worship, posts, pipelines, existing roads and railway lines, stream/river/canal crossings, cross-drainage structures, etc. that are likely to affect the project proposals should be located by means of offsets measured from the traverse line. Where the survey is for improving or upgrading an existing road, measurements should also be made for existing carriageway, roadway and location and radii of horizontal curves. In case of highways in rolling and hilly terrain the nature and extent of grades, ridges and valleys and vertical curves should necessarily be covered. The width of land to be surveyed will depend on the category of road, purpose of the project, terrain and other related factors. Generally, the survey should cover the entire right-of-way of the road, with adequate allowance for possible shifting of the centre line from the traverse line.

8.2.6. Levelling work during a preliminary survey is usually kept to the minimum. Generally, fly levels are taken along the traverse line at 50 metre intervals and at all intermediate breaks in ground. To draw contours of the strip of land surveyed, cross-sections should be taken at suitable intervals, generally 100 to 250 m in plain terrain, upto 50 m in rolling terrain, and upto 20 m in hilly terrain. To facilitate the levelling work, bench marks, either temporary or permanent, should be established at intervals of 250 to 500 metres. The levels should be connected to GTS datum.

8.2.7. Field notes of the survey should be clear and concise, yet comprehensive enough for easy and accurate plotting.

8.2.8. Apart from traverse survey, general information about traffic, soil, drainage should be collected while the traverse is being run, as mentioned in para 8.1.2.

8.2.9. Check list on preliminary survey is available in ***Appendix-4.***

8.3. Map Preparation

8.3.1. Plans and longitudinal sections (tied to an accurate base line) prepared as a sequel to the preliminary survey are referred to for detailed study to determine the final centre line of the road. At critical locations, like, sharp curves, hair-pin bends, bridge crossings, etc., the plan should also show contours at 1-3 metre intervals, particularly for roads in rolling or hilly terrain so as to facilitate the final decision.

8.3.2. Scales for the maps should generally be the same as adopted for the final drawings. The following scales are suggested:

(i) Built-up areas and stretches in hilly terrain-1:1,000 for horizontal scale and 1:100 for vertical scale.

(ii) Plain and rolling terrain-1:2,500 for horizontal scale and 1:250 for vertical scale.

8.3.3. For study of difficult locations, such as, steep terrain, hair-pin bends, sharp curves, bridge crossings, etc. it may be convenient to have plans to a larger scale than recommended above. If necessary these plans may show contours preferably at 2 m interval, though this could be varied to 1.5 m according to site condition.

9. ENVIRONMENTAL IMPACT STUDY AND RESETTLEMENT AND REHABILTATION ACTION PLAN

9.1. General

9.1.1 The Environmental Impact Assessment (EIA) has become an integral part of highway project preparation work. The main purpose of EIA is to identify the environmental impact of the project proposal and its different alternatives, weigh their significance and severance, propose possible mitigating

measures and provide necessary information for taking decision regarding the overall acceptability of the project from environmental angle.

9.1.2. The subject is being briefly described in the following paragraphs but in all cases of actual project preparation the provision in the "Guidelines for Environmental Impact Assessment of Highway Projects" (IRC:104) together with relevant guidelines and instructions issued by the Ministry of Environment and Forests shall be followed as guiding principles.

9.1.3. The EIA comprises mainly of the following four elements:

(i) Preliminary Screening and Environmental Analysis

(ii) Environmental Design

(iii) Compliance of Coastal Regulation Zonal requirements

(iv) Environmental Management Action Plan

In most cases the second element i.e. Environmental Design within its Scope will have a brief socio-economic base-line study, assessment of special requirements of Forests and Coastal Regulatory Zones and preparation of a Resettlement and Preliminary Rehabilitation Action Plan (RAP) may become necessary.

9.1.4. Interalia the following legislation need due consideration:

- Environmental (protection) Act, 1986
- Wild life (protection) Act 1972
- Forest (conservation) Act, 1980
- Water (prevention and control of pollution) Act ,1981 (amended 1987)
- Air (prevention and control of pollution) Act ,1981 (amended 1987)
- Coastal Zone Regulation

The latest versions/amendments shall be used.

9.1.5. The provisions in the Notification of the Government of India in Ministry of Environment and Forest N.O. S.O. 318 (E) published in Gazette Extraordinary N.O. 244 dt. 10-4-1997 shall also be kept in view. ***The projects relating to improvement works including widening and strengthening with marginal land acquisition of roads along the existing alignments irrespective of the cost component is exempted from obtaining environmental clearance from Ministry of Environment and Forest.***

9.1.6. Salient features of MOEF "Environmental Guidelines for Highway Projects" are covered in ***Appendix-11.***

9.2. **Environmental Analysis**

9.2.1. A preliminary environmental/screening of the highway may be carried out to determine the magnitude of actual and potential impact and ensure that environmental considerations are given adequate weightage in the selection and design of the highway improvement/construction proposals.

In ***Appendix-5***, a chart for Initial Environment Examination (IEE) and suggested grading and protection measures have been indicated.

9.2.2. Information should be collected on existing environmental conditions and a preliminary evaluation of the alignment selected for improvement/construction in order to determine the focus of

environmental assessments, design and management studies.

9.2.3. Positive and negative impacts of upgrading the highway or constructing a new highway shall be identified. Cost-effective measures may be proposed to enhance the positive impacts and to avoid or mitigate the effect of negative impacts.

9.2.4. Where felt necessary, public consultation with the affected groups or involved NGO's may be carried out.

9.3. **Environmental Design**

9.3.1. From the Environmental analysis all elements with potential for adverse impacts should be identified, for which steps can then be taken to avoid/mitigate through judicious design changes (e.g., shifting the road alignment to save trees on one side of the road). Adverse impacts, such as, soil erosion, flooding, loss of vegetation cover, etc. should be identified and appropriate mitigating measures, like, ground cover planting, installation of proper drainage system, etc. incorporated in design to reduce the impact. Cost effective proposals may also be included in the design proposal to suitably upgrade or enhance the environmental quality along the highway or the new alignment in a sustainable manner. Where possible a few stretches along the project road may be selected for provision of facilities for non-motorised transport which may provide an indirect encouragement to enhancement of environmental quality.

9.4. **Environmental Management Action Plan**

9.4.1. An implementation schedule and supervision programme may be prepared for timely execution of environmental mitigation and design works and all efforts may be made to stick to it.

In important cases the programme for monitoring environmental impacts during construction and operation should be developed.

For large projects, the requirement for institutional strengthening and training facility for personnel to be deployed on environmental works should be specified.

Any further studies of environmental issues, which are required to be undertaken during project implementation should be recommended.

9.5. **Resettlement and Rehabilitation Action Plan (RAP)**

9.5.1. Whenever the project will entail acquisition of land, structures and other assets and cause displacement or loss of assets within the public right-of-way, the project should undertake a socio-economic base-line study and prepare a Re-settlement and Rehabilitation Action Plan (RAP).

9.5.2. Broadly speaking, the RAP has three main objectives:

(a) To assess and bring out the impacts of land acquisition and assets for the project civil works on the people who own properties in the area to be acquired or live on the land to be acquired and/or derive their income from the land or own enterprises operating on the land to be acquired,

(b) To present the entitlement policy for compensation and assistance to people affected by the project, and

(c) To prepare an action plan for delivery of compensation and assistance outlined in the policy to the persons duly identified as entitled to such assistance.

9.5.3. The present policy of the Government is that the population adversely affected by the project should receive benefits from it or at the least, they should not be worse off than before because of

the project. Since acquisition of land and other assets may be unavoidable and an integral part of project design and implementation, undertaking a social impact assessment and preparing RAP may also be included as a part of project design from the start and undertaken in close co-ordination with environmental analysis and environmental action plan. Also, as far as possible, involuntary settlement may be avoided or at least minimised wherever possible, by exploring other alternative project designs.

9.5.4. The initial screening of social and environmental impacts should be a part of final selection of alignment. In this connection the initial Environmental Examination grading suggested in the table in ***Appendix-5*** may be seen.

9.5.5. In cases where displacement, loss of assets or other negative impacts on people are unavoidable, the project should assist the affected persons with means to improve their former living standards, income-earning capacities, production levels or at least maintain the previous standards of living.

9.5.6. Since no civil work can be undertaken on any stretch of road before land acquisition and payment of compensation as per RAP, it is essential that planning and implementation of civil works may be co-ordinated with RAP.

9.5.7. Preparation of RAP requires a thorough understanding of the local people, and the social, economic and cultural factors influencing their lives. It is essential that detailed base-line studies are conducted with a participatory approach through consultation with potentially affected persons and other stake holders in the area, the local NGO's, municipal authorities, etc. and a mutually satisfactory solution is achieved.

10. FEASIBILITY REPORT

10.1. A Feasibility Report is prepared after the preliminary survey is completed. The report is intended to serve as the basis for according Administrative Approval (AA) for the project by the Highway Department/Public Works Department. When International funding is sought, it forms the basis for entering into negotiations with the funding agency and concluding an agreement for loan. The Feasibility Report must establish the economic viability and technical soundness of the alternative selected. Thus, it must be preceded by the engineering surveys and investigations of sufficient accuracy and detail as to result in a fairly firm estimation of the cost of the project. It must be based on accurate traffic projections and must contain an economic analysis.

10.2. A full account of the socio-economic profile of the state and the Road Influence Area must be given in the Feasibility Report. The transport infrastructure of the stage must be fully described, giving details of the road/road transport sector.

The Feasibility Report may include discussion on different alternative alignments, alternative pavement design for deciding the one most suitable as final option.

Feasibility of stage construction should also be examined in the light of the rate of growth of traffic and other relevant parameters.

10.3. A brief outline of the organisational structure of the Public Works Department must be given, establishing its adequacy in handling the project and giving details of any augmentation support system proposed.

10.4. The Report should give a brief description of the scope of the project, its need, sources of funding, budget and plan provision, selection of route alignment, cross-sectional elements, drainage facilities and construction technology.

10.5. The methodology adopted for the various studies must be described. These include traffic surveys: soils; materials and sub-soil investigation; hydrological and drainage studies.

10.6. The design standards and methodology adopted must be explained.

10.7. The Report must contain a reasonably accurate estimate of costs, giving the basis for adopted rates. Any provision for escalation of costs must be explained.

10.8. The implementation programme involving prequalification, bidding, construction supervision and contract management must be drawn up and presented in the form of bar chart.

10.9. The economic analysis must be based on current costs. The IRC Manual on Economic Analysis of Highway Projects (Special Publication No.30) gives details of the procedure that may be adopted. Some other models like HDM III or its latest revision developed by the World Bank, RTIM III developed by Transport Research Laboratory U.K. after suitable calibration for Indian conditions also can be used if so desired. A sensitivity analysis must be presented for the following cases:

(1) Benefits minus 15 per cent
(2) Base costs plus 15 per cent
(3) Base benefits minus 15 per cent and base costs plus 15 per cent
(4) Implementation delay:one year

These percentages are generally specified in the range of 10-15 per cent.

In addition to catering for the uncertainties in the generated and diverted traffic, a sensitivity analysis shall be carried out considering the non occurrence of the development envisaged and/or the diverted traffic not attracted as per assumption. For cost benefit assessment, the sensitivity analysis shall include:

- Base Case
- Pessimistic Scenario
- Optimistic Scenario

10.10. The construction arrangements envisaged must be discussed. The procedure for prequalification of contractors and for bidding and supervision arrangements must be discussed.

10.11. In case of Build, Operate and Transfer (BOT) Projects, the financial analysis with different financial scenarios must be presented. The financial analysis may include cash flows, minimum construction time and exploring other revenues including the tolls.

10.12. The Feasibility Report must be accompanied by the following drawings:

(i) Locality map
(ii) Plans showing various alternative alignments considered and the selected alignment
(iii) Typical cross-sections showing pavement details
(iv) Drawings for cross-drainage and other structures
(v) Road junction drawings
(vi) Strip plan
(vii) Preliminary land acquisition plans

10.13. The Feasibility Study shall have following broad coverage:

Volume I-Main Text and Appendices

(i) Executive summary
(ii) Regional/State socio-economic profile
(iii) Socio-economic profile of the project influence area
(iv) Methodology adopted for the studies
(v) Traffic surveys and analysis
(vi) Engineering survey investigations and analysis
(vii) Project road description and or improvement proposals
(viii) Environmental impact assessment
(ix) Resettlement and rehabilitation action plan
(x) Project cost estimates including L.A. cost
(xi) Economic analysis and evaluation including sensitivity
(xii) Conclusions and recommendations

Volume II-Design Report

(i) Project road inventory
(ii) Engineering survey and investigation data
(iii) Design standards and specifications.
(iv) Pavement and bridge design

Volume III-Drawings

10.14. A check list for the Feasibility Report is given in ***Appendix-6.***

11. SELECTION OF OPTIMUM ALIGNMENT IN THE DESIGN OFFICE

11.1. Determination of the final centre line of the road in the office is a forerunner to the final location survey. This involves the following operations :

(i) Making use of the maps from preliminary survey (see para 8.3) showing the longitudinal profile, cross-sections and contours, a few alternative alignments for the final centre line of the road are drawn and studied and the best one satisfying the engineering, aesthetic and economic requirements selected.
(ii) For the selected alignment, a trial gradeline is drawn taking into account the controls which are established by intersections, railway crossings, streams and other drainage requirements. In the case of improvements of an existing road, the existing road levels are also kept in view.
(iii) For the selected alignment, a study of the horizontal alignment in conjunction with the profile is carried out and adjustments made in both as necessary for achieving proper co-ordination.
(iv) Horizontal curves including transitions with adequate provision for visibility are designed and final centre line marked on the map.
(v) The vertical curves are designed and the profile determined.

11.2. The alignment determined in the design office shall be cross checked in the field, specially when the data base is not adequately updated.

11.3. Determination of the final centre line of the road forms the appropriate stage for preparing plans and estimates for land acquisition. Land acquisition proceedings involve time and these need not wait till the preparation of the detailed project report especially, if administrative approval has already been obtained.

12. FINAL LOCATION SURVEY

12.1. Purpose

12.1.1. The purpose of the final location survey is to lay out the centre lines of the road in the field based on the alignment selected in the design office and to collect necessary data for the preparation of working drawings. The completeness and accuracy of the project drawings and estimates of quantities depend a great deal on the precision with which this survey is carried out. The accuracy of the survey should be test checked by the senior professionals of the concerned authority. This will also generate the precise land acquisition requirements.

12.1.2. The two main operations involved in the survey are the staking out of the final centre line of the road by means of a continuous survey and detailed levelling.

12.2. Staking Final Centre Line

12.2.1. The centre line of the road, as determined in the design office, is translated on the ground by means of continuous transit survey and staking of the centre line as the survey proceeds. Double reversal method should be adopted at all horizontal intersection points (H.I.P.) and intermediate points of transit (POT) on long tangents. The H.I.Ps. should be fixed on hubs driven flush with the ground and suitably referenced so that they may be readily located. Usually, these should be serially numbered for easy identification and shall be defined by coordinates. On long tangents, the intermediate transit points (POTs) should also be fixed on hubs in the case of new roads, and by means of spikes or nails driven into the pavement in the case of existing roads with proper referencing. Method of referencing H.I.Ps. and POTs is illustrated in Fig.12.1 and is also shown in ***Plate-2.***

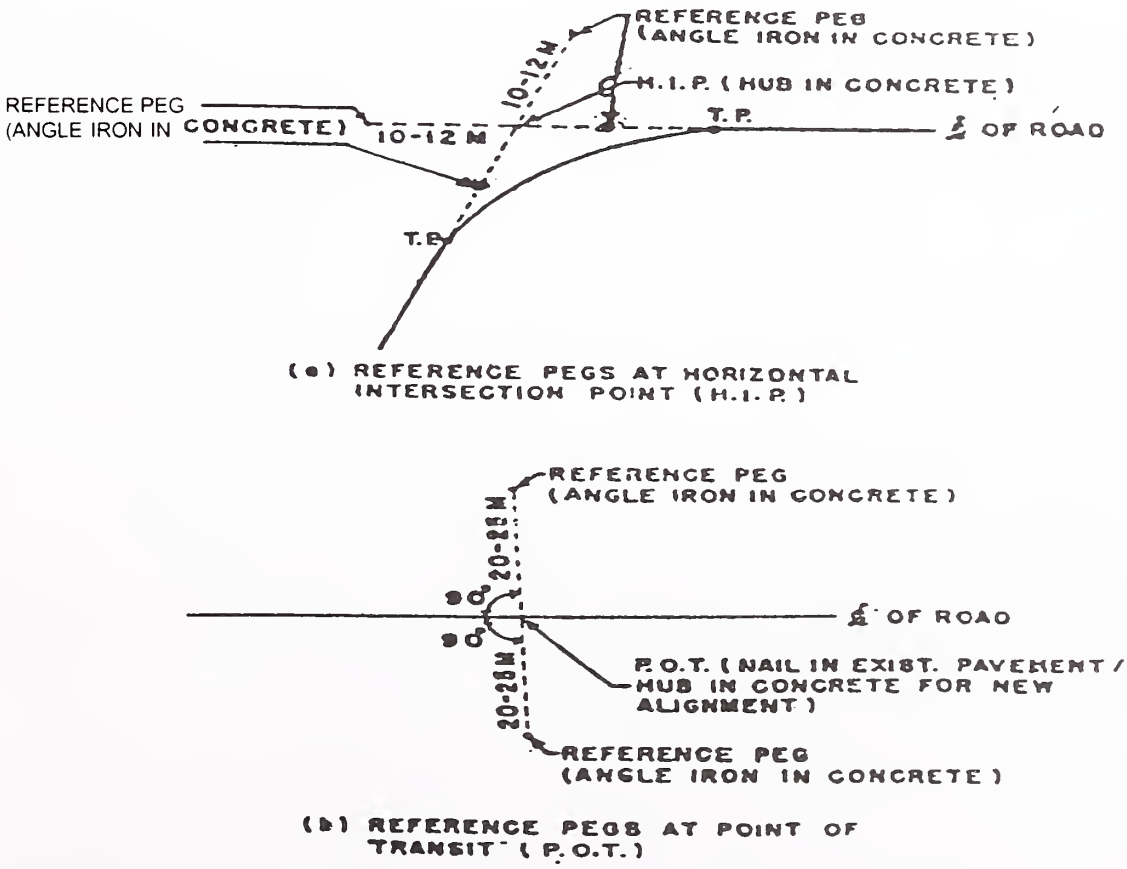


Fig. 12.1. Sketches explaining the method of referencing horizontal intersection point (H.I.P.) and point of transit (P.O.T.)

12.2.2. The reference points should be so located that these will not be disturbed during construction. Description and location by coordinate of the reference points should be noted for reproduction on the final plan drawings.

12.2.3. All the curve points, namely the beginning of spiral transition curve (BS), beginning of circular curve (BC), end of circular curve (EC) and the end of spiral transition (ES) should be fixed and referenced in the same manner as for POTs described earlier. (For the procedure of setting curves, reference may be made to IRC:38 "Design Tables of Horizontal Curves for Highways").

12.2.4. The final centre line of the road should be suitably staked. Stakes should be fixed at 50 metre intervals in plain and rolling terrain, and 20 metre intervals in hilly terrain. The stakes are intended only for short period for taking levels of the ground along the centre line and cross-section with reference thereto. In the case of existing roads, paint marks with button headed steer nails may be used instead of stakes.

12.2.5. Distance measurements along the final centre line should be continuous following the horizontal curves where these occur.

12.2.6. The traverse in case of road alignment would be open and should be controlled by establishing control points to be established by sophisticated G.P.S. or by astronomical observations or by running cut-off lines between certain intermediate stations.

12.2.7. At road crossings, the angles which the intersecting roads make with the final centre line should be measured. Similar measurement should be made at railway level crossings.

12.3. **Bench Marks**

12.3.1. To establish firm vertical control for location, design and construction, permanent bench marks should be established at intervals of 2 km and temporary bench marks has intervals of 250 metres (exceptionally 500 metres), and at or near all drainage or underpass structures. Reference points for POTs and HIPs, as shown in Fig. 12.1 could also be used as bench marks. It is particularly important that a single datum, preferable GTS datum, should be used to tie up all the levels. For bench mark levelling, check levels should be run over the entire line back to the first bench mark.

12.4. **Longitudinal Sections and Cross-Sections**

12.4.1. Levels along the final centre line should be taken at all staked stations (Refer sub-para 11.4.2) and at all breaks in the ground.

12.4.2. Cross-sections should be generally taken at 50-100 metre intervals to plain terrain and 50-75 metre in rolling terrain depending on the nature of work. Preferred distance for existing roads are built-up situations is 50 m. The interval should be still less in hilly terrain, about 20 m. In addition, cross-sections should be taken at points of beginning and end of spiral transition curves, at the beginning, middle and end of circular curves, and at other critical locations. All cross-sections should be with reference to the final centre line, extended normally up to the right-of-way limit, and show levels at every 2-5 metres intervals and at all breaks in the profile.

12.4.3. Centre line profile should normally be continued at least 200 metres beyond the limits of the project. This is intended to ensure proper connecting grades at both ends. With the same objective, profile along all intersecting roads should be measured upto a distance of about 150 metres. Further, at railway level crossings, the level of the top of the rails, and in the case of subways, the level of the roof

should be noted. On existing roads, levels should be taken at all points of intersection in order to help the fixation of profile.

12.5. Proper Protection of Points of Reference

12.5.1. The final location survey is considered complete when all the necessary information is available and ready for the designer to be able to plot the final road profile and prepare the project drawings. Among other things, field notes should give a clear description and location of all the bench marks and reference points. The information should be transferred to the plan drawings, so that at the time of construction the centre line and the bench marks could be located in the field without any difficulty.

12.5.2. At the time of execution, all construction lines will be set out and checked with reference to the final centre line established during the final location survey. It is important, therefore, that not only all the points referencing the centre line should be protected and preserved but these are so fixed at site that there is little possibility of their being disturbed or removed till the construction is completed.

12.5.3. A checklist indicating the major operations involved in the different types of survey and investigation for a road project is given in ***Appendix-4.***

13. SOIL AND MATERIALS SURVEYS

13.1. General

13.1.1. Investigations for soil and other materials required for construction are carried out in respect of the likely sources and the availability and suitability of materials. Some other investigations, for instance in respect of landslide prone locations may also be conducted at this stage.

13.1.2. In particular soil and materials surveys are required:

(i) to determine the nature and physical characteristics of soil and soil profile for design of embankment and pavement

(ii) to determine the salt content in soil in areas known to have problems or where the composition of the design crust requires such testing

(iii) to determine the proper method(s) of handling soils

(iv) to classify the earthwork involved into various categories such as rock excavation, earthwork in hard soil etc.

(v) to gather general information regarding sub-soil water level and flooding; and

(vi) to locate sources for aggregates required for pavement and structures and to ascertain their availability and suitability for use.

(vii) locate source of good quality water suitable for use in different items and work particularly the current work.

13.2. Study of Available Information

13.2.1. The soil and materials location surveys should include study of all available information such as geological maps, data published by the various authorities regarding location of construction materials and the information available with ground water authorities regarding depth of water table. Soil maps prepared by the local agricultural department and records of existing highways may also provide useful information. A study of these data, if available, will be of great help in the planning and conduct of further surveys and investigations. This information should be perused in conjunction with general information gathered during the preliminary survey (see para 8.1.2).

13.2.2. After studying the available information, detailed programme of survey can be drawn up. Points needing attention during detailed soil survey are highlighted further on.

13.3. Soil Investigations for Low Embankments

13.3.1. The first operation in the detailed soil survey is to demarcate the possible borrow areas. While demarcating borrow areas within the road land, the directions contained in IRC:10 "Recommended Practice for Borrowpits for Road Embankment Constructed by Manual Operation" should be kept in view. The extent of borrow areas should be commensurate with the volume of work involved in the embankment.

13.3.2. The general character of material excavated from test pits should be recorded and tests conducted on it in the laboratory for properties mentioned further on. Where the type on material varies in a single pit, the tests should be conducted on each type of soil separately and the horizon of occurrence noted. Similar tests should be carried out on material from cuts for ascertaining the suitability of its use in the embankment.

(i) Gradation test (IS:2720 Part IV)
(ii) Liquid limit and Plastic limit (IS:2720 Part V)
(iii) Density and optimum moisture content (IS:2720 Part VII or Part VIII as relevant)
(iv) Deleterious constituents (only in salt infested areas or where presence of salt is suspected) (IS: 2720 Part XXVII)

However, in case of highly plastic poorly draining and unstable soils, some additional soil tests, (e.g. shrinkage limit test) may also need to be performed before accepting the same either for foundation or borrow.

13.3.4. The results of the laboratory investigations should be summarised in a convenient form for which a proforma is suggested in Table 1. Usually this information should be enclosed in full with the project report. Based on results of the tests, sand content, and classification of the soil vide IS system, (as discussed in paras 3.10 to 3.13 of IRC:36) should also be determined. The final selection of the borrow areas, whether for the body of the embankment or the subgrade could then be made in accordance with the norms recommended in IRC:36 "Recommended Practice for the Construction of Earth Embankments for Road Surface". Great caution should be exercised to ensure and mark, as far as possible, homogenous soils only for this purpose. Heterogeneous or variable soils should be avoided. In making the selection it should be ensured that the best available homogeneous, soil is reserved for use in the subgrade (i.e., top 500 mm portion of the embankment). After completing the analysis of the results, borrow area charts similar to the sample shown in Fig.13.1 should be prepared.

Table 1. Suggested Proforma for Presenting Laboratory Investigation Data of Soil for Embankment Construction

Name of the Laboratory/Institute: .....

Name of the Technician : .....

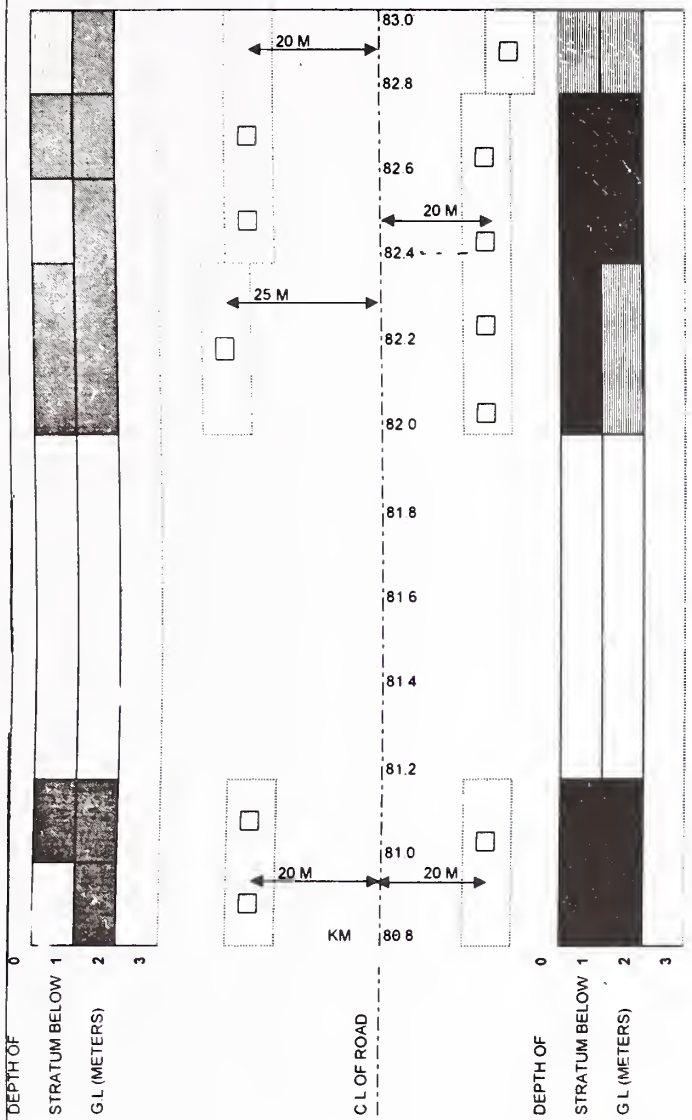
Date	Location	Type of soil	Sieve analysis Percent passing				Sand (per cent) content (Col. 4) - (Col. 7)
			4-7mm sieve	2mm sieve	425 micron sieve	75 micron	
1	2	3	4	5	6	7	8

Atterberg limits (per cent)			Soil Classification	Density Test		Deleterious Constituents	Remark
L.L.	P.L.	P.I		Max. dry Density g/cc (Normal/ Heavy Compaction)	OMC per cent		
9	10	11	12	13	14	15	16

Note: If desired, the classification could alternatively be done according to the IS system of classification. See paras 3.10 to 3.13 of IRC:36 Recommended Practice for the Construction of Embankment of Road Works in this Regard.

Only in salt infested areas the presence of salt is suspected.

LINEAR CHART
NOT TO SCALE



REACH	ESTIMATED FILL		SOURCE OF PROCUREMENT OF EARTH FOR								REMARKS
	FOR SUB-GRADE	FOR BODY OF EMBEN-KMENT	SUBGRADE & SHOULDER FROM				BODY OF EMBANKMENT FROM				
			BORROW AREAS		REACHES OF CUTTING		BORROW AREAS		REACHES OF CUTTING		
KM - KM	CUM	CUM	LOCATION KM	QUANTITY CUM	LOCATION KM	QUANTITY CUM	LOCATION KM*	QUANTITY CUM	LOCATION KM	QUANTITY CUM	
81.0 - 81.2	1000	6000	-	-	81.3	1000	@	6000	-	-	
81.2 - 81.4	400	1000	-	-	81.3	400	-	-	81.3	1000	
81.4 - 81.6	400	2000	-	-	81.5	400	-	-	81.5	2000	
81.6 - 81.8	400	-	-	-	81.7	400	-	-	-	-	
81.8 - 82.0	800	4000	@	400	81.8	400	@	4000	-	-	
82.0 - 82.2	1000	5000	@	1000	-	-	@	5000	-	-	
82.2 - 82.4	900	8000	@	900	-	-	@	5000	-	-	
82.4 - 82.6	500	4000	82.2	500	-	-	@	4000	-	-	
82.6 - 82.8	100	2000	82.9	100	-	-	@	2000	-	-	
82.8 - 83.0	100	2500	@	100	-	-	@	2000	-	-	

@ FROM ADJOINING BORROW AREAS

LEGEND

- TEST PITS
- BORROW PITS
- SOIL TO BE RESERVED FOR TOP 500 mm OF SUBGRADE AND EARTHEN SHOULDERS
- SOIL SUITABLE FOR BODY OF EMBANKMENT
- SOIL CONSIDERED UNFIT FOR EMBANKMENT CONSTRUCTION

NOTE : THE QUANTITIES GIVEN IN THE TABLE ARE APPROXIMATE.

STATE :
ROUTE No.:
SECTION :

BORROW AREA CHART
KM 81.0 - 83.0

Fig. 13.1. Borrow Area Chart

13.4. Special Investigations for High Embankments

13.4.1. The basic objective of investigations in such cases is to obtain engineering data for soil and rock necessary for a quantitative design of embankment at the chosen sites. Generally for checking stability against slip failures, the basic properties to be investigated are shear parameters, unit weight and moistures conditions. For safety against excessive settlement, consolidation properties are important. For investigations in such cases, services of specialists may often be needed. Reference may also be made to IRC publication "Guidelines for the Design of High Embankments" (IRC:75).

In addition to the above, some special considerations required have been enumerated in ***Appendix-1*** to this manual for locating roads in hilly areas, desert areas, water-logged areas and areas subject to soil erosion. These points may be kept in view.

IRC Special Report No.13 State of Art : High Embankment on Soft Ground Part-A- Stage Construction Contains recommendations for foundations for high Embankments. Special Report 14 entitled State of the Art High Embankments on Soft Ground- Part-B- Ground Improvement. The points mentioned in them would be of help in preparation of projects in similar situations. Software HED Version 1.0 (available with the IRC) for design of high embankment is recommended for analysis. Slope stability analysis for seismic forces and reinforcement force can be handled by this software. This software is with Graphic Capability

List of laboratory tests to be conducted for highway embankment is placed as ***Appendix–10.***

Ministry of Road Transport and Highways circular No. NH-VI-50(21)/79 dated 25th January, 1980 regarding "Investigation and Design for High Embankments at Approaches to Bridges and Overbridges on National Highways and other Centrally Financed Roads" has been printed with 17 Annexures in Addendum to Ministry's Technical Circulars and Directives on National Highways and Centrally Sponsored Road and Bridge Projects published by IRC. This circular is very exhaustive and covers basic steps and procedures for soil investigation, typical worked out example for stability analysis of embankments, filter design, settlement analysis, etc.

13.5. Soil Investigations for Cut Sections

13.5.1. In the same manner as described in para 13.4 for embankment material, soil in cut sections along the centre line of the road at an elevation corresponding to the design subgrade level should be tested for the following general properties:

(i) Gradation

(ii) Atterberg limits

(iii) Field density and moisture content

(iv) Proctor density

13.5.2. In the case of rock cuts where necessary, trial pits or boreholes should be made to the foundation level, to make realistic estimates of the type of cutting involved. The interval of trial bores may be 30 to 50 metres or as otherwise decided by the Engineer-in-charge depending on specific requirements.

13.6. Special Investigations in Landslide-Prone Areas

13.6.1. Information collected during preliminary survey (see para 8.1.2) would normally identify the landslide prone areas along the alignment and every effort would have been made to avoid these while

fixing the centre line of road. However, in case where the same is not feasible, further investigations would be required to study the extent of the problem and plan appropriate remedial measures. For this purpose, services of geologist or soil specialist may often be needed.

13.6.2. Depending on the geological configuration and drainage of the area, slides may take the form of rock or soil fall (i.e., movement of detached rock fragments at steep angles), rock flows (i.e., soil or rock mass suddenly losing strength and flowing like a liquid), or rotational slides (i.e., slips triggered under-cutting, erosion, external load on upper parts of the slope, or water seepage). Investigation in each case will, therefore, depend on site conditions and the type of slide expected. These will involve collection of information about the existing slides, sources of water in the area, substrata profile, and other pertinent data which may facilitate inferences being drawn as to the cause, mechanism, and potentiality of slides. For detailed guidance in regard to such investigation, reference might be made to standard publications on the subject and IRC Special Report No.15 – "State of the Art: Landslide Correction Techniques".

13.7. Detailed Investigation for Flexible Pavement Design

13.7.1. New flexible pavements are to be designed in accordance with IRC:37 "Guidelines for the Design of Flexible Pavements". General principles laid down in this publication for moulding and testing soil specimens under different situations to be able to use the CBR method of design should be kept in view.

13.7.2. For new roads, the soil data already collected in earlier phases of the survey should be studied in detail for ascertaining the variability/homogeneity of the soil profile, and planning further investigations. Where pavement design relates to widening/strengthening of an existing road, the road should be divided into more or less identical sections on the basis of actual performance and pavement composition, as the basis for further testing.

13.7.3. For pavement design, apart from the general soil tests referred to earlier, CBR test should be conducted for soaked, unsoaked or both these conditions depending on the design requirements spelt out in IRC:37.

Frequency of CBR testing may be decided based on the soil classification tests conducted at close interval of 500 m-1,000 m.

Overall objective should be to get strength results for all changes in soil type or each demarcated section of similar performance.

13.7.4. A suggested proforma for presenting soil investigation data pertinent to flexible pavement design is given in Table 13.2.

13.7.5. In case of overlay design, IRC Publication "Tentative Guidelines for Strengthening of Flexible Pavements Using Benkelman Beam Deflection Technique–IRC:81" may be followed. A suggested proforma for Pavement Deflection Data Using Benkelman Beam attached in this chapter may be found useful.

13.8. Detailed Investigation for Rigid Pavement Design

13.8.1. For design of cement concrete pavement in the case of new construction, 'K' value tests

Table 13.2: SUGGESTED PROFORMA FOR RECORDING SOIL INVESTIGATION DATA FOR FLEXIBLE PAVEMENT DESIGN

Average Annual Rainfall :
State :
Route :
Section

Date of Sampling	Location		Nature of soil (visual identification)	Sieve analysis:% by weight passing			Sand content (Col.5 Col.7)	Atterberg Limits			Max. dry density gm/cc.	OMC %	Field dry density at subgrade level (for existing roads on new roads in cutting)	** CBR of remoulded soil samples tested without soaking	** CBR of remoulded soil samples soaked in water for 4 days	Depth of water table below sub-grade under worst condition (m)	Remarks
	Km.	Cut/fill/ existing road		4.75 mm sieve	4.25 mm sieve	75 micron sieve		Liquid Limit (LL) %	Plastic Limit (PL) %	Plasticity Index (PI)							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Note: **The moulding density (whether Proctor density or field density), and the testing condition of samples (soaked or unsoaked) will depend on the nature of circumstances and design requirements. In some cases only unsoaked CBR values may be needed in others only soaked values, and in some, both unsoaked and soaked values. Both columns 15 & 16 do not therefore have to be filled in each and every case. For further guidance in this regard, references should be made to IRC:37-2001 "Guidelines for the Design of Flexible Pavements".

Table 13.3: SUGGESTED PROFORMA FOR RECORD OF TEST VALUE OF AGGREGATES LIKE STONE METAL, ETC.

State :
District :
Date of Testing :

Location and name of quarry if any (correlated with index map)	Type of Rock (General group, classification or trade name)	Specimen* No.	Los-Angeles** Abrasion Value (IS:2386-Part IV)	Aggregate Impact Value**		Water Absorptions (IS:2386 Part III)	Flakiness Index***(IS:2386 Part I)		Stripping Value**** (IS:6241)	Remarks regarding performance of the aggregate wherever a systematic evaluation has been made	Addl. Remarks like old/new quarry, approximate quantity available, existing access to quarry etc.
				Dry test (IS:2386 Part IV)	West test (IS: 5640		Normal size 40 mm	Nominal size 20 mm			
1	2	3	4	5	6	7	8	9	10	11	12
		Average									
		Average									
		Average									

Note: * For every quarry source, at least 3 specimens should be tested for each type of material met with.
** For hard aggregates, like, stone metal, any one of the two tests given in colums 4 & 5 may be conducted. Wet test in column 6 has to be done in the case of soft aggregates like laterite, kankar, brick metal etc.
*** Not required to be carried out for soft aggregates, like, laterite, kankar, brick metal, etc.
**** To be performed only when the material is to be used in bituminous constructions.

should be carried out with 75 cm diameter plate at the rate of generally, one test per km per lane unless foundation changes warrant additional tests. Further guidance in this respect can be had from IRC:58 "Guidelines for the Design of Rigid Pavements for Highways".

13.8.2. For investigations in connection with the strengthening of existing rigid pavements, reference may be made to the IRC Special Publication 17 "Recommendations About Overlays on Cement Concrete Pavements".

13.9. Naturally Occurring Aggregates for Pavement Courses

13.9.1. The survey for naturally occurring materials, like, stone aggregates, murum, gravel, kankar, etc., to be employed in construction should embrace the identification of suitable quarries for these, the amount of material likely to be available from each, and the determination of physical and strength characteristics, of the materials. The tests to be conducted and sample proforma for presenting the test results are shown in Tables 13.3 and 13.4, Table 13.3 is for aggregates while Table 13.4 is for naturally occurring materials, like, murum, gravel and soil-gravel/murum mixtures. For every quarry source, at least three specimens should be tested for each type of material met with. Samples for the tests should be representative and collected in accordance with the procedure setforth in IS:2430. Quarry charts showing the location of quarries and the average lead of materials should also be prepared.

New road construction as well as essential maintenance and rehabilitation of existing network use substantial quantity of material resources, like, earth, stone metal, chips, binder, etc. On one hand material extraction, processing and production invariably have adverse impact on environmental and also leads to progressive depletion of existing resources. On the other hand there are many heavy industries, like, steel plants, power plants, etc. which produce a large quantity of waste materials, like, slag, fly ash, bottom ash, etc. which pile up in the absence of satisfactory disposal constituting an environmental hazard. Road research has shown that these waste materials, like, slag, fly ash, etc. can be gainfully utilised in various ways in construction of embankment, pavement, etc. which will not only be economical in certain areas but also will solve the disposal problem. Keeping in mind the environmental need and over-all economy in use of material resources, project preparation should aim at maximum utilisation of these substitute materials in the construction process.

13.10. Manufactured Aggregates (Brick Aggregate)

13.10.1. Where the use of brick aggregates is envisaged, a survey should be made to identify the location and average lead from the work site of existing kilns capable of producing overburnt bricks/brick bats. Where suitable kilns are not in operation, the survey should indicate the possibility of opening new kilns for the purpose.

13.11. Manufactured Items

13.11.1. For manufactured items, like, lime, cement, steel and bitumen, information about their sources of supply and the distance of the nearest rail-head from the location of works should be gathered during the survey. For lime, in addition to source and lead, the information should cover its purity.

13.12. Water for Construction Purposes

13.12.1. Information should also be gathered about the availability of water near the work site and its suitability in conformity with IS:456 for construction purposes.

Table 13.4: SUGGESTED PROFORMA FOR RECORD OF TEST VALUES OF NATURALLY OCCURRING SOIL-GRAVEL/MOORUM MIXTURES

State :
District :
Date of Testing :

Location and name of quarry if any (correlated with index map)	General description of the material	Specimen No.	Gradation:Per cent by weight passing the Sieve (IS:2720-Part IV)							Atterberg limits (IS:2720-Part V)			Proctor Test (IS:2720-Part VII)			CBR value***	Addl. Remarks, like, old/ new quarry, approximate quantity available, existing access to quarry, etc.
			80 mm	40 mm	20 mm	10 mm	4.75 mm	2.36 mm	600 micron	75 micron	Liquid Limit (LL) %	Plastic Limit (PL) %	Plasticity Index (PI)	Density	OMC		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		1															
		2															
		3															
		Average															
		Average															
		Average															

Note: *** Tested in accordance with IS: 2720 Part XVI on samples prepared at Proctor density, OMC and soaked in water for 4 days

PAVEMENT DEFLECTION DATA USING BANKELMAN DEAM
(AS per IRC:81-1997)

Name of Road :

Section :

No. of traffic lanes :

Date and Time of Observation :
Climate conditions (hot/humid/cold) :

Air temprature, °C :

Annual rainfall, mm :

Whether temperature currection is in the applied : Yes/No

whether currection for seasonal variation is to be applied : Yes/No

Sl. No.	Location of test points and identification of lane	Pavement temprature C	Type of Soil and Pt	Moisture content %	Dial range reading			Rebound Deflection
					Initial	Intermediate	Final	
1	2	3	4	5	6	7	8	9

14. ROAD INVENTORY AND CONDITION SURVEY

14.1. Many highway projects involve improvement to an existing road (strengthening/widening) or construction of new facilities (bypasses) which are an improvement in traffic conditions over the existing facility. In all these cases, the scope of the improvement measures and economic justification for them depends upon the condition of the existing road. It therefore, becomes necessary to prepare a road inventory and carryout condition survey.

Suggested formats are indicated in the ***Appendix–7.***

14.2. In some Highway Department/Public Works Department, systematic data on roads and bridges is maintained and updated periodically. They are known as Road Registers and Bridge Registers. For national highways and many state highways there is an existing system of inventorisation. Wherever available these data may be consulted and made use of.

14.3. The best way of preservation of collected data is to keep them in a computer based road data bank. With the proliferation and increasing use of computers of different denominations in engineering works, this may soon become the usual method. With this expectation in view in ***Appendix-8*** is placed a brief note on introduction of computer based road data bank.

14.4. In case the above sources are not available, a fresh road inventory shall have to be prepared. The scope of the inventory would depend upon the nature of the improvements proposed. Condition survey or riding quality will, however be required even if inventory data is available. For economic analysis, the major road characteristics needed are:

(i) Riding quality

(ii) Pavement width

(iii) Vertical profile

(iv) Horizontal curvature

For pavement strengthening projects, information on the subgrade soil strength and pavement thickness and composition are needed. Deflection characteristics (by Benkelman Beam or other Instruments) are also required.

The riding quality is measured by a bump integrator or roughometer. The pavement width is easily measured. The vertical profile and horizontal curvature are measured quickly by car-mounted instruments or can be evaluated from topographical survey. In case the roughometers are not available, the riding quality or the roughness in term of International Roughness Index (IRI) can be reasonably estimated by subjective evaluation base on **World Bank Technical Paper Number 46**. The guidelines for such roughness assessment are given in Figs. 14.1 and 14.2.

For correlation with 5th Wheel Bump Integrator values the following relation as given in HDM-III Volume-1 may be used.

$$BI = 630\,(IRI)\,1.12$$

where, BI = Roughness in mm/km

IRI = Roughness in m/km

ROUGHNESS
(m/km IRI)

Ride comfortable over 120 km/h. Undulation barely perceptible at 80 km/h in range 1.3 to 1.8. No depressions, potholes or corrugations are noticeable; depressions < 2 mm/3 m. Typical high quality asphalt 1.4 to 2.3, high quality surface treatment 2.0 to 3.0.

Ride comfortable up to 100-120 km/h. At 80 km/h, moderately perceptible movements or large undulations may be felt. Defective surface: occasional depressions, patches or potholes (e.g. 5-15 mm/3 m or 10-20 mm/5 m with frequency 2-1 per 50 m) or many shallow potholes (e.g. on surface treatment showing extensive ravelling). Surface without defects: moderate corrugations or large undulations.

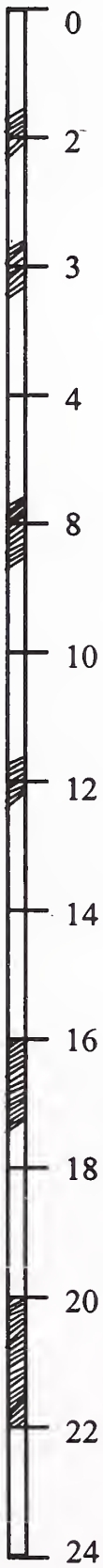
Ride comfortable up to 70-90 km/h, strongly perceptible movements and swaying. Usually associated with defects: frequent moderate and uneven depressions or patches (e.g. 15-20 mm/3 on or 20-40 mm/5 m with frequency 5-3 per 50 m), or occasional potholes (e.g. 3-1 per 50 m). Surface without defects: strong undulations or corrugations.

Ride comfortable up to 50-60 km/h, frequent sharp movements or swaying. Associated with severe defects: frequent deep and uneven depressions and patches (e.g. 20-40 mm/3 m or 40-80 mm/5 m with frequency 5-3 per 50 m), or frequent potholes (e.g. 4-6 per 50 m).

Necessary to reduce velocity below 50 km/h. Many deep depressions, potholes and severe disintegration (e.g. 40-80 mm deep with frequency 8-16 per 50 m).

Fig. 14.1. Road Roughness Estimation Scale for Paved Roads with Asphaltic Concrete or Surface Treatment (Chipseal) Surfacings

ROUGHNESS
(m/km IRI)



Recently bladed surface of fine gravel, or soil surface with excellent longitudinal and transverse profile (usually found only in short lengths).

Ride comfortable up to 80-100 km/h, aware of gentle undulations or swaying. Negligible depressions (e.g < 5 mm/3 m) and no potholes.

Ride comfortable up to 70-80 km/h but aware of sharp movements and some wheel bounce. Frequent shallow-moderate depressions or shallow potholes (e.g. 6-30 mm/3 m with frequency 5-10 per, 50 m). Moderate corrugations (e.g. 6-20 mm/0.7-1.5 m).

Ride comfortable at 50 km/h (or 40-70 km/h on specific sections). Frequent moderate transverse depressions (e.g. 20-40 mm/3-5 m at frequency 10-20 per 50 m) or occational deep depressions or potholes (e.g. 40-80 mm/3 m with frequency less than 5 per 50 m). Strong corrugations (e.g. > 20 mm/0.7-1.5 m).

Ride comfortable at 30-40 km/h. Frequent deep transverse depressions and/or potholes (e.g. 40-80 mm/1-5 m at freq.- 5-10 per 50 m); or occational very deep depressions (e.g. 80 mm/ 1-5 m with frequency less than 5 per 50 m) with other shallow depressions. Not possible to avoid all the depressions except the worst.

Ride comfortable at 20-30 km/h. Speeds higher that 40-50 km/h would cause extreme discomfort, and possible damage to the car. On a good general profile: frequent deep depressions and/or potholes (e.g. 40-80 mm/1-5 m at frequency 10-15 per 50 m) and occasional very deep depressions (e.g. > 80 mm/0.6-2 m). On a poor general profile: frequent moderate defects and depressions (e.g. poor earth surface).

Fig. 14.2. Road Roughness Estimation Scale for Unpaved Roads with Gravel or Earth Surface

15. DRAINAGE STUDIES

15.1. General

15.1.1. Drainage of highway refers to the satisfactory disposal of surplus water within the highway limits. The water involved may be precipitation falling on the road, surface runoff form the adjacent land, seepage water moving through sub-terranean channels, or moisture rising by capillary action. Adequate information about drainage patterns is necessary to devise an effective drainage system, which brings into focus the need for requisite studies and investigations.

15.1.2. Drainage studies have the following principal objectives:

(i) fixing the grade line of the road

(ii) design of pavement, and

(iii) design of the surface/sub-surface drainage system

15.1.3. Main components of the drainage investigation are determination of HFL and ponded water level, depth of water table, range of tidal levels and amount of surface runoff. Besides this, for cut sections in rolling and hilly areas, it would be necessary to carry out special investigations for sub-terranean flows and seepage of irrigation water from fields situated above the road.

15.1.4. Extent of studies and the data to be collected will depend on the type and scope of the project. Usually good deal of information could be collected through site inspection, simple measurements and local enquiry. Most appropriate time for such enquiries is during the stage of preliminary survey (see section 8) so that the information gathered can be of use in fixing the alignment and finalising the broad strategy for improving the drainage. Detailed investigations could continue till the final location survey when any adjustment in the light of further data could still be made before the project in finally ready. In the case of cut sections, investigations for seepage and sub-terranean flows may generally have to be done again at the stage of formation cut when new features may come to light warranting modifications in design or the need for special measures.

15.2. High Flood Level

15.2.1. HFL governs the grade line of a road and its reasonably precise estimation is particularly important. The design HFL should be based on a return period depending upon the importance of the structure. Information in this regard can normally be had from the irrigation department who maintain and analyse such data. Inspection and local enquiry can often provide very useful information, such as marks left on trees or structures indicating the maximum flood level. HFLs so determined should also be compared with those for the adjoining sections of the road or nearby railway/irrigation embankments to correct any mistake.

15.2.2. Construction of a highway embankment may sometime block the natural drainage paths and cause a heading up on the water on upstream side. In finalising the HFL, due allowance for the possible afflux in such circumstances must be made. Adequate number of openings shall be provided.

15.3. Depth of Water-Table

15.3.1. Knowledge of the high water-table (for various return periods) is necessary for fixing the subgrade level deciding the thickness of pavement, and taking other design measures such as provision of capillary cut-offs or interceptor drains. Depth of water-table may be measured at open wells along the alignment or at holes specially bored for the purpose. Usually observations should be taken at intervals of one kilometre or less, preferably at the time of withdrawal of the monsoon, when the water -table is likely

to be the highest. If there is any evidence of spring flow in the test holes, this should be carefully recorded. The depth of water-table should be measured with reference to a common datum.

15.3.2. Besides high water-table it may be helpful to know the fluctuations in water-table. For this purpose, measurements of the lowest water-table in the driest month should also be made.

15.3.3. In areas where the climate is arid and the water-table is known to be at least one metres below the general ground level, depth of water table need not be measured.

15.4. **Ponded Water Level**

15.4.1. In situation where water stagnates by the roadside for considerable period, e.g., irrigated fields etc., information about the level of standing water should also be collected and considered for design in conjunction with HFL and water-table.

15.5. **Special Investigations for Cut-Sections**

15.5.1. In cut sections in rolling or hilly terrain, the problem of seepage flows is common. The seepage water may be due to high water-table, sub-soil water moving through sub-terranean channels where a permeable soil layer overlies an impermeable stratum, or irrigation water in adjoining fields situated at a higher level . Where such conditions exist, it may be necessary to intercept the seepage flow to prevent saturation of the road bed .

15.5.2. Preventive measures in this regard can consist of deep side drains of open or French type (to check sideway seepage or lower the water-table), buried transverse drains (to cut-off the longitudinal sub-surface flow, underneath the pavement, especially at the transition from cut to fill sections), or blanket course/sub-drains below the pavement in combination with side drains (to protect the pavement form excess hydraulic pressure). Actual treatment in each case will depend on factors such as the intensity of seepage, depth of the permeable strata etc., for which investigations would be required.

15.5.3. Analysis of water-table information (see para 14.3) in conjunction with the surface profile will indicate the possible problematic areas as regard seepage flows. As an adjunct to this, ground within the highway limits should be surveyed soon after the rainy season to visually identify the seepage zones, normally characterised by wet areas and patches. The following detailed investigations could then be taken up at these locations to decide the appropriate drainage measures against seepage:

(i) Soil profile of the area i.e. soil type and the depth of various strata.

(ii) The head under which seepage water is flowing and its hydraulic gradient. This could be measured through a series of stand pipes placed in observation holes.

(iii) Permeability tests on strata through which the ground water is flowing.

15.5.4. It is desirable that investigations for seepage flows may have to be repeated during execution, particularly at the stage of formation cut, when it may be possible to make a closer examination to locate the seepage areas more accurately. The additional observations may warrant changes in the original design or the need for special measures.

15.6. **Surface Run-off**

15.6.1. Surface run-off to be catered for includes precipitation on the highway itself and flow from the adjoining areas. Run-off is ultimately led away form the highway area to the natural drainage

channels by means of side drains. For the design of these drains, the following investigations, would need to be carried out:

(i) Study of ground contours of the land adjacent to the highway for determining the catchment contributing to the flow in side drains.

(ii) Determination of the surface characteristics of catchment area, i.e., the type of soil, vegetation, slopes etc., and

(iii) Study of ground contours for locating the outfall points.

15.6.2. For further guidance about the design of surface drainage system, reference may be made to the "IRC Code of Practice for Road and Airfield Drainage".

16. CROSS-DRAINAGE STRUCTURES

16.1. For cross-drainage structures, i.e., culverts, surveys and investigations are carried out essentially for:

(i) Selection of site, and

(ii) Collection of data for design of the structure.

16.2. Selection of Site

16.2.1. By and large the siting of culverts should be guided by the geometric features of the road alignment unless there are specific problems of location and design. Where defined channels are existing for watercourses, the culverts may be located on that. In case of provision of waterway only for balancing purposes along a flat featureless terrain, the spacing and location may be for achieving the best balancing work along the design geometric alignment. Where there is a choice, the following points should be kept in view:

(i) The site should be on a straight reach of the stream sufficiently below bends.

(ii) The location should be as far away from the confluence of the large tributaries as possible. So as to be beyond their disturbing influence.

(iii) The bands should be well defined.

(iv) As far as possible the site should enable a straight alignment and a square crossing.

16.3. Collection of Data for New Structures

16.3.1. For designing culverts, hydrological, physical and foundation data are required to be collected. In addition, site inspection with local enquiry and a study of the nearby road or railway cross-drainage structures on the same stream or in the vicinity, will provide useful information about HFL, afflux, tendency to scour, the probable maximum discharge, the likelihood of collection of brush-wood during floods, foundation problems, etc.

16.3.2. The essential data needed for design of new culverts are :

(i) **Catchment Area:** Where the catchment, as seen from the topographic sheet, is less than about 1.25 sq.km. in area traverse should be made along the watershed with a chain and compass. Where the area is flat without defined watershed, it would first be necessary to conduct a local contour survey to identify the watershed before taking up the traverse for larger catchments, the area can be measured from the 1:50,000 topographic maps by using a piece of transparent square paper or planimeter.

(ii) **Cross-sections:** As a rule, for a sizeable stream, three cross-sections should be taken, one at the selected site, one upstream and another downstream of the site, all to the horizontal scale

of not less than 1/1000 and exaggerated vertical scale of not less than 1/100. Approximate distance upstream and downstream of the selected site where cross-sections may be taken as shown in Table 5.

Table 5

Catchment area	Distance (u/s & d/s of the crossing) at which cross-sections should be taken
2.5 sq.km.	150m
From 2.5 to 10 sq.km.	300m
Over 10 sq.km.	400 m to 1600 m

The cross-section at the proposed site of the crossing should show levels at close intervals and indicate outcrops of rock, formation of pools, scourholes etc. where and existing road or a cart-track crosses the stream at the selected site, the cross-section should not be taken along the centre line of the road or the track as that will not represent the natural shape and size of the channel. Instead the cross-section should be taken a short distance upstream or downstream.

In the case of very small streams (Catchments of 40 hectares or less), one cross-section may do but it should be carefully plotted so as to represent truly the normal size and shape of the channel on a straight reach.

(iii) **The Maximum HFL:** The maximum high flood level should be ascertained by intelligent local observation, supplemented by local enquiry and marked on the cross-sections.

(iv) **Longitudinal Section:** The longitudinal section should extend upstream and downstream of the proposed site upto the cross-section mentioned in (iii) above and should show levels of the bed, low water level and the HFL.

(v) **Velocity Observation:** Attempts should be made to observe the velocity during an actual flood, but if that flood is smaller than the maximum flood, the observed velocity should be suitable increased. The velocity thus obtained is a good check on the accuracy of velocity calculated theoretically.

(vi) **Trial Pits:** Where rock or some firm undisturbed soil stratum is not likely to be far below the bed of the stream, a trial pit should be dug upto the rock or firm soil. But if there is no rock or undisturbed firm soil close to the stream bed level, then the trial pit should be taken down roughly up to twice the maximum depth of the existing or anticipated scour line. The location of each trial pit should be shown in the cross-section of the proposed site. The trial pit section should be plotted to show the kind of soils passed through. Where trial pits are not possible because of longer depths or for other reasons, trial bores should instead be made. For very small culverts, one trial pit will be sufficient.

16.4. Design of Cross-drainage Structure

16.4.1. The steps involved in the design of cross-drainage structures include:

(i) Estimation of design discharge

(ii) Choice of type of structure to be provided

(iii) Determination of waterway and vent height

(iv) Structural design of foundations, sub-structure and super-structure.

For details of the design procedure, reference may be made to IRC 13 "Guidelines for the Design of Small Bridges and Culverts".

For design of minor bridges, reference may be made to IRC:78 on "Foundation and Sub-structure" and relevant MOST Standard Drawings for Super-structure.

16.5. Data where Improvement to Existing Drainage Structures are Proposed

16.5.1. The existing drainage structures proposed for improvement should be surveyed and data collected on the following points:

(i) Type of structure and details of span, vent height etc.

(ii) Existing width of roadway

(iii) Condition of foundations, sub-structure, super-structure, parapets etc. and any deficiency to be rectified

(iv) Load carrying capacity of the structure

(v) Adequacy/inadequacy of waterway, signs of silting or blocking of the ventway, over topping of the structure, observed scour level, pattern, etc.

16.5.2. The data collected should be presented in a tabular form along with proposals for correcting deficiencies.

17. PREPARATION AND PRESENTATION OF PROJECT DOCUMENTS DETAILED PROJECT REPORT (DPR)

17.1. General

17.1.1. The project data collected during the survey and investigation together with the proposal worked out on that basis should be presented in a proper form for full appreciation by the appropriate authority. These should be prepared in three parts under the following headings which when read together will constitute the complete project document:

(i) The Report

(ii) Estimate

(iii) Drawings

Details to be presented in each part are brought out in subsequent paragraphs for guidance. It should, however, be understood that the extent of detailing of an individual aspect would depend upon the size of the concerned project and its scope, e.g., whether new construction or improvement to an existing road.

17.2. Project Report

The Project Report is one of the most important parts of the project document and should give a precise amount of the different features for easy understanding and appreciation of the proposals. The information provided may be conveniently dealt with under the following heads:

(i) Executive summary

(ii) Introduction

(iii) Socio-economic profile

(iv) Traffic surveys including traffic forecasts

(v) Engineering surveys and investigations, and proposed road features

(vi) Pavement studies

(vii) Design standards and specifications

(viii) Drainage facilities including cross-drainage structures

(ix) Environmental and social considerations including rehabilitation and resettlement

(x) Materials, labour and equipment

(xi) Rates and cost estimates

(xii) Economic analysis and financial analysis (where required)

(xiii) Construction constraints and programme

(xiv) Miscellaneous

(xv) Conclusions and Recommendations

The design calculations, etc. with regard to the above items should be attached.

17.2.1. **Executive Summary:** Executive summary will summarise the entire report. All the salient points will be included. The executive summary should be such that a top executive is able to know all the features of the project that are required for decision making.

17.2.2 **Introduction:** This should cover:

(i) **Name of the work and its broad scope:** Information here should give a general idea of the scheme as a whole.

(ii) **Authority and plan provision:** Give reference to the order of the competent authority calling for the project and the provision for the work in the relevant development plan.

(iii) **History, geography, climate, dimography, etc.**

Previous history of the road and its present condition (in the case of existing roads) or development history for project as regards economic activity, population served, available transport facilities, etc. (in the case of a new roads).

Highlight aspects such as prone to flooding of the area, waterlogging, etc.

The general topographical and geological features of the area.

Rainfall, annual average intensity and distribution during the year, range of temperature during summer and winter months periods of low and high water levels in river/canal, etc.

(iv) **Necessity:** Indicate the necessity for the project and the circumstances which have made its execution urgent.

17.2.3. **Socio-economic profile:** This should cover Socio-economic profile of the region and the Project influence Area (see Section 5)

17.2.4. **Traffic surveys and traffic forecasts:** Discuss the type of traffic surveys conducted for various sections, the data collected and the results of future growth. Present the design traffic figures separately for each element of the project, e.g., width of carriageway, pavement, intersections, railway crossings, etc. For existing roads, discuss the accident data with special reference to the known accident-prone location.

17.2.5. **Engineering surveys and investigations and proposed road features:** Description under this head should inter-alia cover:

(i) **Route Selection**

Considerations governing the route selection and the effect of the proposed route on the overall transportation pattern of the area with respect to other facilities, like, railways, inland waterways, etc. (in the case of new roads). Discuss the merits and demerits of alternative routes investigated and reasons for selecting the proposed route.

(ii) **Alignment**

The general alignment of the road and its details, section by section, with reference to topographical and geological features, obligatory points, such as, bridge sites, important

population centres, existing or prospective industrial centres, etc. Also, discuss points of general importance, like, high banks, heavy cuttings, nature of gradients, radii of curves, sight distance, nature of soil along that alignment, etc.

(iii) **Roadland, roadway, carriageway and other cross-section elements**

Discuss the proposals regarding right-of-way, acquisition of structures alongside roadway, carriageway width, etc. In the case of existing roads, compare the cross-sectional elements with the existing widths.

(iv) In case of the existing roads or where relevant, the above subject should cover aspects, such as, road inventory, road condition survey, geo-technical investigations, bridge inventory study, bridge condition survey, etc.

17.2.6. **Pavement studies**

(i) **Road Design**

Bring out the special features of road design, e.g., fixation of grade line vis-a-vis HFL/Water table, high embankments, treatment of cut sections, design of road junctions, removal of geometric deficiencies in the case of existing roads, remedial measures for land-side prone location, etc. Attach design calculations where necessary. Discuss any deviations from the prescribed standards, with reasons for the same.

(ii) **Pavement Design**

Present the soil investigation data for pavement design in a tabular form (including Benkelman Beam deflection data, if collected in the case of existing roads). Discuss the methodology of collecting these data and bring out the pavement design proposals with respect to the alternatives considered.

(iii) **Masonry Works (other than C.D. Works)**

Bring out the proposal for retaining walls, breast walls, pitching, parapet walls, railings, etc. Attach design calculation where required.

17.2.7. **Designs standards and specifications:** Give reference to the standard specifications, in accordance with which the works are proposed to be executed. Highlight where any modifications are proposed or special specifications are advocated.

17.2.8. **Drainage facilities including cross-drainage structures**

(i) Discuss the investigations carried out for designing the drainage measures and bring out the salient points in respect of H.F.L., water-table, ponded water level, seepage flows, closure periods incase of canals, etc.

(ii) Give details of the surface/sub-surface drainage measures proposed, e.g., longitudinal side drains, catch water drains, longitudinal transverse sub-drains, blanket courses, etc. Attach design calculations/drawings as necessary.

(iii) Highlight if any special measures are proposed to check soil erosion and assist soil conservation.

(iv) Discuss the proposal regarding small cross-drainage structures, i.e., culverts. Give details of the proposed structures in a tabular form with cross reference to the standard designs adopted on the detailed drawings enclosed. The table should also indicate special features of each structures like design HFL, deck level, waterway, etc. Attach water-way calculations.

(v) In case of improvement to existing roads list out the cross-drainage structures proposed to be improved/widened/reconstructed with details of improvement and justifications.

(vi) State whether the structures to be built with regard to standard designs. If so, give reference to the relevant drawings. Otherwise , attach design calculations and drawings.

17.2.9. **Environmental and social consideration including R&R:** Significant beneficial and detrimental impact of the proposed works on the environment in terms of air pollution, damage to life

system, stream pollution, soil erosion, drainage pattern, landscaping, etc. Discuss the planning and design measures proposed to minimise/eliminate the adverse effects. Discuss also the resettlement and rehabilitation action plan.

17.2.10. **Material, labour and equipment**

(i) **Materials**

Present the results of the soil and materials survey with reference to various sections of the road, bringing out clearly the sources from which the materials are to be obtained and their suitability of use in the works. Attach borrow material charts, quarry charts, results of tests on materials, etc. Discuss the facilities for transport of materials, and how these are to be provided.

(ii) **Labour**

Discuss the requirements of labour for the work, whether it is to be imported, skilled labour needed, housing facilities, etc.

(iii) **Equipment**

List the total equipment required for the implementation of the project. The list of equipment required to be maintained after construction, like, settlement gauge for high embankments.

17.2.11. **Rates and cost estimates**

(i) Give reference to the Schedule of Rates adopted and the year of its publication. Indicate whether the schedule is current or any corrections have to be applied. The schedule of rates must be realistic including the cost of machinery input, etc. to avoid revision of estimates.

(ii) Bring out the items for which suitable rates are not available in the schedule and for such items give reference to the analysis of rates attached to the estimate.

17.2.12. **Economic and financial analysis (where required):** The DPR must contain the economic analysis carried out establishing the viability of the project. For details a para 10.9 may be referred to. Where required, financial analysis may also be given.

17.2.13. **Construction programming**

(i) Mention whether the work is proposed to be executed departmentally or through contract, period proposed for completion of the project. Constraints, if any which might possibly upset this schedule may be mentioned and plan to encounter them discussed.

(ii) Draw up a construction schedule, either in the form of a bar chart or on the basis of critical path method (CPM). For details of the latter, reference may be made to IRC Special Publication No.14.

(iii) Cash flow requirements for the proposed construction schedule should be mentioned.

17.2.14. **Miscellaneous items**

(i) **Wayside Amenities:** To increase the efficiency of work of truck drivers, for provision of better comfort and hygienic conditions at rest places to make essential items needed during travel, like, good food, first-aid, medical assistance, recreation, essential repair items for vehicles of both truckers as well as travelling passengers and tourists rest places with wayside amenities are required to be provided at suitable intervals. Complexes with wayside amenities for truck drivers, cleaners and other people attached to the carrier vehicles and also complexes with passenger oriented amenities are constructed for this purpose. These complexes also may provide at reasonable charges telephones, reading rooms, recreation and indoor sports rooms in addition to rest place, toilet, refuelling and repair arrangements. The average distance between the complexes and their size and capacity will be determined by the intensity of the traffic flow along the highway.

(ii) **Parking Places:** Provision of adequate areas of parking spaces at suitable locations is an important feature of road networks, particularly in urban situations. On rural highways also, depending upon the intensity of traffic, parking places are required to be provided in complexes with wayside amenities for trucks as well as passenger cars and tourist vehicles. On busy roads when vehicle break-down occurs, the immobilised vehicle needs to be pulled upon the extreme edge of the road embankment so that it does not in any way interfere with the traffic flow. Near fuelling stations, rest or units with other type of amenities for travellers or truckers, there should be suitable lay-bys adjacent to the highway.

(iii) **Traffic and Traffic Safety:** The number of accidents occurring on our roads and the number of lives lost in road accidents is one of the highest in the world. Consequently, the total economic loss to the country is huge even excluding the cost of delay, pain, deprivation and suffering, etc. for which it is difficult to make economic evaluation. Pursuant to the national targets for reduction in accidents and fatalities, it is necessary to make provisions for traffic safety in the design and estimates of the project.

It is commonly said that traffic safety is dependant on provision of three E's, i.e., Engineering, Enforcement and Education. In the project preparation stage care can be taken only on the engineering aspect. Geometric and structural provisions in the project should, therefore, conform to the engineering standards and elements essential for the design speed, capacity, etc. of the concerned project. Since pedestrians and cyclists constitute a large percentage of the fatalities, specially on urban roads, adequate safety provisions, like, segregation, provision of side-walks, footpaths, cycle tracks, crossing facility at intersection, proper lighting, etc. where relevant, shall, have to be provided.

The MORT&H has published a " Manual for Safety in Road Design - A Guide for Highway Engineers", the suggestions of which should be kept in view during project preparation. Also, no compromise or corner-cutting shall be allowed on provision of adequate road signs, road marking and use of other suitable traffic safety aids.

(iv) **Safety Audit:** Depending upon the importance of the project, where considered necessary, arrangement for competent safety audit on the design and engineering provisions may be made for experts advice by some eminent consultant or professional organisations.

(v) **Toll Plazas:** For collection of tolls or fees for using a particular highway facility it is often necessary to construct suitable toll plazas on the highways. The location, construction and operation of the plazas should be such that it does not substantially impede the traffic flow, takes the least amount of time in collecting the toll and in every possible way be efficient and convenient to the road user.

For construction of toll plazas on National Highways, the Ministry of Surface Transport has from time to time circulated several guidelines, the most well known of which are those under Ministry's letter No.33054/7/88-S&R dt. 4-11-92. The circular contains general guidelines for planning, construction and operation of modern toll plazas on National Highways including procedural details for selection of an appropriate design, layout, construction keeping in view traffic, terrain and type of operating system desired (manual, semi-automatic) and the likely period for collection of toll.

(vi) **Dumping Grounds:** One of the essential requirement of road planning and design is to make proper provision for utilisation of unwanted surplus materials resulting from construction excavations in earth work and rock, etc. are normally tried to be adjusted between cut and fill sections or utilisation low level areas within reasonable leads. Where no such thing is possible or if the surplus material is of unwanted nature (like, dismantled old road crust, elements of dismantled structures, stumps and root system for trees, rejected bituminous mixes, etc.) these require to be dumped in specially earmarked places. Depending upon the requirement of space suitable fallow land or naturally depressed low lands in need of filling may be identified within easy and economic leads for dumping of such materials. The project estimate may make suitable provisions for such arrangement.

The DPR may contain an assessment of the requirement of various miscellaneous items, their type design and suitability of location, etc., like the following:

(i) Rest houses and temporary worksheds;

(ii) Diversion and haul roads;

(iii) Arrangement for water supply and other site amenities;

(iv) Traffic control devices, e.g., signs, pavement marking, guard stones, kilometre stones, etc.

(v) Roadside plantations, turfing, landscaping, wayside amenities, etc.;

(vi) Tourist facility items, such as, parking/scenic lay-bys;

(vii) Safety in construction zone;

(viii) Toll plaza.

17.2.15. **Conclusions and Recommendations:** This should cover conclusions and recommendations about the project as a summary.

17.3. **Estimate**

17.3.1. The project estimate should give a clear picture of the financial commitment involved and should be realistic. This is possible only if the items of work are carefully listed, the quantities determined to a reasonable degree of accuracy, and the rates provided on a realistic basis.

17.3.2. The estimate should consist of;

(i) **General abstract of cost:** This should give the total cost of the scheme with a general break-up under major heads (with further sub-divisions as necessary), e.g., land acquisition; site clearance, earthwork, sub-bases and bases, bituminous work/cement concrete pavement; cross-drainage and other miscellaneous structures; miscellaneous items, percentage charges for contingencies, work-charged establishment, quality control, etc. The General Abstract of cost should also include the cost of shifting utilities, like, electric lines, telephone poles, underground cables, gas lines, sewers, water pipes, cost of arboriculture, cost of removal of trees and compensatory afforestation.

(ii) **Detailed estimates for each major head:** These should consist of

(a) abstract of cost

(b) estimate of quantities

(c) analysis of rates for items not covered by the relevant schedule of rates; and

(d) quarry/material source charts.

17.3.3. Where a project work is proposed to be executed in stages, the estimate should be prepared for each stage separately.

17.3.4. The matter presented should follow a logical sequence.

17.3.5. Where provision for escalation has been made, its basis should be explained.

17.4. **Drawings**

17.4.1. **General:** Project drawings should depict the proposed works in relation to the existing features, besides other information necessary for easy and accurate translation of the proposals in the fields. For easy understanding and interpretation, it is desirable that the drawings should follow a uniform practice with regard to size, scales, and the details to be incorporated.

17.4.2. **Drawing size:** Drawings should be adequate size to accommodate a reasonable length of the road or a structural unit in full details. At the same time, these should not be inconveniently large to

necessitate several folds. From this angle, it is recommended that preferably the size may be 594x420 mm or 420x297 mm corresponding to A2, A3 respectively, as per IS: 696 -1960. Drawings of this size could be stitched in a folder with flexible covers so that the folio can be rolled for convenient handling. On sheet of A2 size, it will be possible to accommodate the plan and L-section of one km length of the road, with sufficient overlap on either side and on sheet of A3 size, it will be possible to accommodate the plan and L-section of 750 m length of the road,with sufficient overlap on either side, if drawn to the horizontal scale of 1:2500. A wider margin of 40 mm may be kept on the left hand side of the drawing to facilitate stitching into a folio.

17.4.3. **Component parts of highway project drawings:** The drawings usually required for a road project include the following:

(i) **Locality map-cum-site plan:** This is combination of a key map and index map drawn on a single sheet. This will be the first sheet in folio of drawings for a particular section of the road. However, where the length of a section is substantial, it may become necessary to separate out the locality map and the site plan. The former being accommodated in one sheet and the latter on a series of sheets.

The locality map (same as key map) should show the location of the road with respect to important towns and industrial centres and the existing means of communication in the neighbourhood so as to give a bird's eyeview of the proposed work. The map may be to a scale of 1:250,000 which is one of the common scales used in Survey of India maps.

The site plan (same as index map) should show the project road and its immediate neighbourhood covering the important physical features, such as, hills, rivers, tanks, railway lines, etc. It may be to a scale of 1:50,000 and should show the, kilometres from the beginning to end.

The sheet containing the locality map-cum-site plan should have a legend to explain the abbreviations and symbols used in subsequent drawing sheets.

One typical example of locality map-cum-site plan may be seen in ***Plate-1.***

(ii) **Land Acquisition Plans:** These should be prepared on existing village maps or settlement maps giving the details of property boundaries and their survey numbers. A scale in the range of 1:2000 to 1:8000 depending on available maps will be suitable. If for any reason detailed land acquisition plans are not possible, rough plans should be prepared. Inter alia, the plans should show the final centreline of the road; and right-of-way boundaries, buildings, wells, monuments, trees, etc. affected by the road alignment, type of land, i.e., irrigated, wet, dry, barren, forest, etc. and the nature of crops.

(iii) **Plan and longitudinal section:** Plan and longitudinal section for one km length of the road should be shown on a single drawing sheet as far as possible the plan should be at the top and the longitudinal section at the bottom. Common scale adopted is 1:2500 for the horizontal, and 1:250 for the vertical, but this may be changed suitably for hilly stretches (also see para 8.3)

The plan, among other things, should show the final centreline of the road, right-of-way limits, roadway of the existing road where applicable, existing structures, drainage, courses, intersecting roads, railway lines, electric and telephone lines, cables, location of cross drainage structures, design details of horizontal curves, bench marks, position of POTs, location of cross sections, contours, north point, etc.

The longitudinal section should show the profiles of the proposed road, the general ground, and the existing road where applicable. In addition, it should show details, such as, the gradients, location and set out data for vertical curves, super-elevation, details of horizontal alignment, the design HFL, location of drainage crossings and intersecting roads, pavement design features, continuous chainage, etc.

The manner of presenting the details on the plan and longitudinal section drawings is illustrated in ***Plate-2*** for 2-lane and in ***Plates-5 & 6*** for 4-lane divided carriageway.

(iv) **Typical cross-section sheet:** In a highway project, cross-section elements, like, width of the carriageway and roadway, side slopes, and pavements cross fall will generally remain constant for most of the road length. Instead of repeating these details on every cross-section, it would be desirable to show these on a typical cross-section sheet. The number of typical cross-sections to be drawn will depend on the type of project, the terrain traversed, etc. Generally, it may be necessary to show at least one cross-section each for road in fill, cut and curve. Sample of a typical cross-section sheet may be seen in ***Plate-3*** for 2-lane and ***Plate-7*** for 4-lane divided carriageway.

These should be drawn to a scale of 1:100.

(v) **Detailed cross-sections:** A few detailed cross-sections may be presented serially along the continuous chainage. These should show the ground levels, existing road levels where applicable, and the proposed road levels. The area of cut and/or fill involved should be indicated as also the type and thickness of the different pavement courses. For rest of the cross-sections computer charts showing tabulated level details and distances may be appended.

The recommended manner of presenting the cross-sections is illustrated in ***Plate-4.***

(vi) **Drawings for cross-drainage structures:** In a highway project, a large number of small cross-drainage structures, (i.e., culverts) will be required to be constructed. Unless, there is a special problem, it should normally be convenient to adopt standard designs for these. If a standard design is not used for any reason, a separate drawing should be prepared for each cross-drainage structure. A convenient scale is 1:50.

For the details to be shown on these drawings, reference may be made to IRC:SP-13 "Guidelines for Design or Small Bridges and Culverts".

(vii) **Road junction drawings:** The junction drawings should show the existing features of the intersecting roads, the proposed improvements, and traffic control devices, like, signs, pavement marking, etc. A scale of 1:500 or 1:600 will be found convenient for this purpose. A typical drawing is shown in ***Plate-8*** for illustration.

(viii) **Drawings for retaining walls and other structures:** These drawings should clearly show the foundation and structural details as also the materials proposed to be used. The scale chosen should be large enough to show all the details comprehensively.

(ix) Drawings of wayside amenities.

(x) Location of various road signs.

17.5. Check List

Appendix-4 gives a check list for the various surveys and investigation work involved in the preparation of a road project. The various items that should be incorporated in a detailed Project Report are shown in the form of a check list in ***Appendix-9*** for guidance. This is intended to serve in a ready reference to ensure that all the items have been included and give an opportunity to the engineer preparing the project to review his work and if necessary to state in the reports why some items have been left out.

Appendix-1

GUIDING PRINCIPLES COVERING ROUTE SELECTION AND HIGHWAY LOCATION

1. **General**

1.1. The highway should be as direct as possible between the cities or towns to be linked, thereby, satisfying the major desired links. A direct highway link results in economy in construction, maintenance and operation.

1.2. The location should result in minimum interference to agriculture and industry.

1.3. The location should, as far as possible, facilitate easy grades and curvature.

1.4. The location should steer clear of obstruction, such as, cemetries, burning ghats, places of worship, archaeological and historical monuments, and as far as possible, from public facilities, like, hospitals, schools, play grounds, etc.

1.5. Where the proposed location interferes with utility, services, like, overhead transmission lines. Water supply lines, etc., decision between changing the highway alignment or shifting the utility services should be based on study of the relative economics and feasibility.

1.6. As far as possible, frequent crossing and re-crossing of a railway line should be avoided. For design requirements in such cases, reference may be made to IRC:39 "Standards for Road-Rail Level Crossings".

1.7. An important obligatory point in the selection of the route is the location of river crossings. While crossings of major rivers (waterway exceeding 200 m.) may have to be as normal to the river flow if possible, with highway alignment sub-ordinated to considerations of the bridge siting. Crossings of medium/minor streams should be generally governed by the requirements of the highway proper. If necessary, such structures could be made skew/ located on curves.

1.8. The location should be such that the highway is fully integrated with the surrounding landscape of the area. In this connection, it would be necessary to study the environmental impact of the highway and ensure that the adverse effects of it are kept to the minimum.

1.9. The highway should, as far as possible, be located along edges of properties rather than through their middle so as to cause least interference to cultivation and other activities and to avoid the need for frequent crossing of the highway by the local people.

1.10. The location should be, such as, to avoid unnecessary and expensive destruction of wooded areas. Where intrusion into such areas is unavoidable the highway should be aligned on a curve if possible so as to preserve an unbroken background.

1.11. The location should, as far as possible, be close to sources of embankment and pavement materials so that haulage of these over long distances is avoided and the cost minimised.

1.12. A preferred location is one which passes through areas having better type of soil and permits a balancing of the cost of cut and fill for the formation.

1.13. Marshy and low-lying land, and areas having poor drainage and very poor embankment material should be avoided, as far as possible. Also, areas susceptible to subsidence due to mining operations should be by-passed.

1.14. Areas liable to flooding should be avoided, as far as possible.

1.15. Highways through villages and towns increase traffic hazards and cause delay and congestion. Wherever a serious problem of this nature is encountered it may be advisable to by-pass the built-up area playing well clear of the limits upto which the town or village is anticipated to grow in the future.

1.16. As far as possible, areas likely to be unstable due to toe-erosion by rivers, shall be avoided.

1.17. During fixing of alignment by the side of a river, the direction of flow of the river and HFL records for past 50 years shall be kept in view.

1.18. In spite of all conscious effort to avoid running through forest areas many times roads are required to be aligned passing through the forest land. With increase in traffic roads require to be widened often leading to cutting of trees on one or both sides of the road. All these unavoidable feeling need to be made good by provision of compensatory afforestation in equal or additional areas at suitable locations. Project preparation needs to keep this aspect in view and make necessary provisions for compensatory afforestation where the same is warranted.

1.19. If prior to project preparation it is known that a facility under construction is to be widened to additional lanes, the project should be prepared by locating the first embankment and pavement in an eccentric position with respect to the total land available and also freeze the total land required for the entire envisaged facility right in the beginning. The subsequent construction may then be undertaken symmetrically with respect to the centre line of the land.

If provision of additional lanes has to be made to an old road, it can be done either by addition of half the requirement symmetrically on each side on the entire new addition on one side only. The points to be considered in such a case are:

(i) the availability of land and convenience of additional acquisition in view of presence of buildings and existing constructions on each side

(ii) felling of trees that may be involved on either side

(iii) the width of new construction and facility of compaction equipment to operate and

(iv) technical convenience for construction of additional structures and necessary protection works for the same in the vicinity of the existing structures

(v) Technical convenience for locations of additional two-lane carriageway proferably on up stream side of the flow of water, providing better protection to the existing facility.

2. Special Problems of Locating in Hilly Areas

2.1. The route should enable the ruling gradient to be attained in most of the length.

2.2. Steep terrain and other inaccessible area should be avoided, as far as possible.

2.3. Unstable hilly features, areas having frequent landslide or settlement problems and up slope benched agricultural field with potential for standing water may be avoided as far as possible.

2.4. Locations, along a river valley have the inherent advantage of comparatively gentle gradients, proximity of inhabited villages, and easy supply of water for construction purposes. However, this solution is be-set with disadvantages, such as, the need for large number of cross-drainage structures and protective works against erosion. It would, therefore, be necessary to take the various aspects into account before making the final selection.

2.5. The alignment should involve least number of hair-pin bends. Where unavoidable, the bends should be located on stable and gentle hill slopes.

2.6. In certain cases, it may be expedient to negotiate high mountain ranges through tunnels. For such cases, the decision should be based on relative economics or strategic considerations.

2.7. In crossing mountain ridges, the location should be such that the highway preferably crosses the ridge at their lowest elevation.

2.8. An alignment likely to receive plenty of sunlight should receive due preference over the one which will be in shade.

2.9. Areas liable to snow drift should be avoided.

2.10. As far as possible, needless rise and fall must be avoided, specially where the general purpose of the route is to gain elevation from a lower point to a higher point.

2.11. Areas of valuable natural resource and wild life sanctionaries shall be avoided.

3. Special consideration for locating roads in desert area

3.1. Locations where sand is loose and unstable should be avoided and the alignment selected along ridges having vegetation.

3.2. Preference should be given to areas having coarse sand than to areas having fine wind blown sand.

3.3. In locating a road in an area having longitudinal sand dunes, the best location is always at the top of a ridge or in the inter-dunal space. Location along the face of longitudinal dunes should be avoided.

3.4. The alignment of road should as far as possible run parallel to sand dunes, sand dunes should be crossed without disturbing their existing profile.

4. Special Considerations in Expansive Soils

4.1. Suitable forms of stabilisation, specially mixing of lime in pulverised soil may be necessary to achieve desired gain in strength.

5. Special Considerations of Road in Saline Soils

5.1. Locations where large salt deposits occur should be bypassed.

5.2. In locating the road in medium and highly saline soil precautions for diversion of water away from road bed should be taken.

5.3. On wet saline soils, highway embankment should be constructed of good imported soil free from salts.

6. Special Consideration in Marine Clay

In case the marine clay site is under the influence of tide rise and fall of water, the subgrade should be 1.0 meter above the highest tidal water level.

Marine clay are soft and compressible. Therefore, stability of fill and the magnitude and time rate of settlement needs to be evaluated and considered. If these factors are not within the acceptable limit ground improvements methods may be adopted.

7. Special Consideration in Water Logged Areas

7.1. Embankment height should be adequately above level of standing water.

7.2. Provision of capillary cut-off or blanket drainage facility below pavement may be necessary.

8. Points of Guidance on Prevention of Soil Erosion needing attention in the Construction of Road in Hilly Areas:

8.1. The road construction project estimates should provide for not only the requisite scale of investigation but also the necessary measures against soil erosion so that these can be built into the project with adequate financial provision.

8.2. Before finalising the alignment erosion potential of each alternative should be carefully examined and the one involving least disturbance to the natural ground should be preferred.

8.3. Roads should not be located in geological by unstable strata, if this can be avoided. Study of the geological maps of the area and consultation with the local Geological Department will be helpful in this regard.

8.4. Road alignment should avoid large scale cutting and filling and follow the profile of the land as far as possible. Use of tunnels to avoid deep cuts should be considered where feasible and economical.

8.5. To the extent feasible, roads should be aligned away from streams except where these are to be crossed, since the greatest damage aways occur along water courses. Special attention is necessary to create protective belts of forests on both sides.

8.6. It will be advisable, at least for important roads, to have consultation with officers of Forest Department at the stages of route alignment selection, surveys and investigations, etc., so as to ensure that the selected alignment has

ninimum potential for soil erosion and that the project designs and estimates provide for the necessary soils erosion ·ontrol measures.

8.7. On hill Slopes half cut and half fill type of cross-section which involves least disturbance to the natural ground, should be adopted subject to consideration of economy and road stability being satisfied.

8.8. The cut slope should be made stable for the type of strata in the initial construction stage itself by resorting to stable cut slopes with benches, etc., including the use of slope stabilising structures, like, breast walls, pitching, etc.

8.9. Area for clearing and grubbing should be kept minimum subject to technical requirements of the road. The clearing area should be properly demarcated to save desirable trees and shrubs and to prevent overclearing.

8.10. Location and aligment of culverts should be so chosen as to avoid adverse erosion at outlets and siltation at inlets.

8.11. The cross-drainage structures should discharge safely on the valley side and in this connection all necessary precautions/safe guards should be taken to ensure that the discharging water does not cause erosion even when they flow for long period.

8.12. Drainage of water from the roadside must be given top attention and necessary system of drains will be received to deal the run-off to natural water courses.

8.13. Appropriate mitigating measures, like, ground cover planting and compulsory afforestation may be catered for.

Appendix-2
(Ref. para 6.9.3)

TRAFFIC GROWTH RATE ESTIMATION

1.1. Traffic growth rate is required to be estimated to assess the future corridor traffic. To be realistic, this projection must be made by considering traffic flow pattern by Origin-Destination pairs and changes in vehicle mix expected during the time horizon of the study. Since the transport demand can change due to shift in the pattern of economic activities, it is also necessary to consider trip generation potentials within a region. In view of this, projecting regional socio-economic characteristics, plus the rate of change likely to take place in the economy, the population size, urbanisation and the spatial distribution of the economic activities are required to be considered in estimation of growth rate for traffic projection. Simple methods which may be considred suitable are described below:

1.2. **Time Trend Analysis**

For this purpose classified volume count data are to be collected at selected survey location which are reasonably representative of the traffic flow conditions along the corridor.

The analysis is then carried out generally by Linear Regression Analysis. A R^2 value of 0.75 or more would be acceptable for forecasting. Erratic and scattered values of R^2 may require consideration of other parameteres and appropriate unbiased purification of data base or adjustment of growth rates, Nevertheless, this method has its limitations particularly in its applications to a new facility. Secondly, historical growth rates do not cover the changes in the socio-economic structure, as such, fail to reflect fully the prospective growth envisaged in the economy and the spatial distribution of economic activities, population size and, urbanization. These may require to have some zonal-level forecasting along the corridor. Thus, something more than simple extrapolation of historical growth rates by vehicle type is required.

1.3. **Systematic Forecasting Method**

This method is more related to the projections of Origin-Destination linkages at the zonal-level, as related to the prospective growth in population and the economy.

The traffic forecasting models developed for the study involve the estimation of future transport demand, in terms of future growth rates based on the growth of population and State Domestic Project (SDP), together with the elasticity of transport demand for both passengers and freight, in relation to income and population.

The data inputs required by this method for the determination of growth rates of vehicular traffic comprise:

(a) the growth of population

(b) income (in real terms) and

(c) the elasticity of transport demand in relation to population and income

The data, particularly the income and transport demand elasticity, are generally not available at zonal level, the state level data may be used with due consideration of the zone under consideration.

1.4. **Simplified Approach**

This appoach is primarily based on the broad guidelines for economic analysis for highway investments circulated for schemes under the proposed assistance by the Asian Development Bank.

Forecast future normal demand for transport by project road based on, but not necessary limited to, annual population and real income per capita growth rates (in per cent per year) estimated in Road Influence Area (RIA), elasticy of transport demand in relation to income, and estimated annual production increases (in per cent per year) in RIA. In other words, annual traffic growth must be related to specific economic activity in each RIA. Transport demand should be projected on an annual basis over the project period. The fornulae for annual growth (in per cent) of passenger vehicles and trucks may be assumed as follows:

(a) Passenger Vehicles

Example: Assumptions

(i) Population growth: 2.1 per cent a year during 1981-91 (expected population growth rates during 1991-2001 2 per cent per year)

(ii) Real income per capita gwoth: 3.0 per cent per year

Then,

Growth Rate (%) = [1.020 x 1.03 -1] x 100 x E

	First Five Years	Second Five Years	Third Five Years
E for Cars, Jeeps and Vans	2.0	2.0	1.8
E for Buses	1.6	1.6	1.5
E for Two and Three wheelers	2.5	2.3	2.1

Where E is the elasticity of transport demand.

(b) Freight Traffic

Estimation of freight traffic is more complex in nature and involves the process of iteration as well as subjective decision so as to be compatible with the regional perspective plans and other indicators. The basic steps will comprise:

(i) From socio-economic profile find out the annual weighted average growth rate in per cent in the agricultural, industrial, mining and tourism sectors (assumed as the predominant sectors) from the State Domestic Product (SDP) data base. This growth may be computed in five (5) year blocks;

(ii) To the above growth rate, apply the elasticity of transport demand. For example

For the first five years 2.0, second five years 1.8 and third five years 1.6;

(iii) Based on the above generate movement quantum in terms of commodity tonnage in the same block of years;

(iv) Now assume percentage of likely market shares by LCV, HCV and MAV during the project period;

(v) Further assign lead distance to connect the commodity movement into tonne-km and using step(iv) generate numbers of vehicles in blocks of five years;

(vi) As a check back calculate the growth rates to examine its appropriateness in the context of regional development perspective and other development parameters. Apply suitable corrections, on subjective basis, to finalise the growth rates and generate annualised traffic streams in terms of LCV, HCV and MAV for use in pavement design as well as economic analysis.

1.4. Conclusion

From the findings of the alternative methods described, appropriate growth rates may be adopted for the project road concerned.

Appendix-3

POINTS ON WHICH DATA MAY BE COLLECTED DURING GROUND RECONNAISSANCE

1. Details of route vis-a-vis topography of the area, whether plain, rolling or hilly.
2. Length of the road along various alternatives.
3. Bridging requirements number, length.
4. Geometrics Features:
   - (a) Gradient that are feasible, specifying the extent of deviations called for
   - (b) Curves hair-pain bends, etc.
   - (c) Railway crossings
   - (d) Ground constraints
5. Existing means of surface travel-mule path, jeep track, earthen cart tracks, railway lines, waterway, etc.
6. Right-of-way available, bringing out constraints on account of built-up area, monuments, and other structures.
7. Terrain and soil conditions :
   - 7.1. Geology of the area
   - 7.2. Nature of soil, drainage conditions and nature of hill slopes
   - 7.3. Road length passing through
     - (i) Mountainous terrain
     - (ii) Steep terrain
     - (iii) Rocky stretches with indication of the length in loose rock stretches
     - (iv) Areas subject to avalanches and snow drifts
     - (v) Areas subjected to inundation and flooding
     - (vi) Areas subjected to sand dunes including location of dunes
     - (vii) Areas of poor soils and drainage conditions
     - (viii) Areas with very poor sub-soil strength, e.g. marshes
     - (ix) Areas of high salinity or wet saline soil
   - 7.4. Cliffs and gorges
   - 7.5. Drainage characteristics of the area including susceptibility to flooding
   - 7.6. General elevation of the road indicating maximum and minimum heights negotiated by main ascents and descents in hill sections
   - 7.7. Total number of ascents and descents in hill sections
   - 7.8. Disposition and location of sand dunes
   - 7.9. Vegetation-extent and type
8. **Climatic Condition**
   - 8.1. Temperature-monthly maximum and minimum readings
   - 8.2. Rainfall data-average annual, peak intensities, monthly distribution (to the extent available)
   - 8.3 Snowfall data-average annual, peak intensities, monthly distribution (to the extent available)
   - 8.4. Wind direction and velocities

8.5. Visibility

8.6. Exposure to sun

8.7. Water Table and its variation between maximum and minimum

8.8. History of unusual weather, like, cloudbursts, etc.

9. **Facilities Resources**

9.1. Landing ground in case of hilly stretches

9.2. Dropping zones in case of hilly stretches

9.3. Foodstuffs

9.4. Labour - local availability and need for import

9.5. Construction material timber, bamboo, sand, stones, shingle, etc. with extent of their availability, leads involved and availability of easy access

9.6. Availability of water, especially in arid zones

9.7. Availability of local contractors

10. Value of land-agriculture land, irrigated land, built-up land, forest land, etc.

11. Approximate construction cost of various alternatives.

12. Access points indicating possibility of induction of equipment.

13. Period required for construction.

14. Strategic considerations.

15. Recreational potential.

16. Important villages, town and marketing centres connected.

17. Economic factors:

(i) Population served by the alignment

(ii) Agricultural and economic potential of the area

(iii) Marketing centres.

18. Other major developmental projects being taken up in the area, e.g, railway project hydro-electric projects, railway projects, dams, reservoirs, mining/agricultural projects, etc.

19. Crossings with Railway Lines and other existing highways.

20. Location of existing or proposed utilities along the alignment.

21. Necessity of by-passes for towns and villages.

22. Position of ancient monuments, burial grounds, cremation grounds, religious structures, hospitals and schools.

23. Ecology and environmental factors.

24. Aspects needing co-ordination with other administrative authorities.

25. Traffic counts from existing records.

Appendix-4
(Ref. paras 8.2..9&12.5.3)

CHECK LIST OF MAJOR OPERATIONS INVOLVED IN THE SURVEY AND INVESTIGATION FOR A ROAD PROJECT

1. **Reconnaissance Survey (See Section 7)**
   (i) Map study
   (ii) Aerial reconnaissance
   (iii) Ground reconnaissance
2. **Preliminary Survey (See Section 8)**
   (i) Collection of general information about traffic, soil, subsoil and surface drainage, etc.
   (ii) Establishment of reference bench marks
   (iii) Traverse survey
   (iv) Fly levels and cross-sections
   (v) Map preparation
3. **Determination of Final Center Line in the Design Office (See Section 10)**
4. **Final Location Survey (See Section 12)**
   (i) Staking of final centre line
   (ii) Referencing HIPs, POTs, etc.
   (iii) Establishment of permanent bench marks
   (iv) Longitudinal and cross-sections
5. **Survey of Economic Profile**
   (i) State's and road influence area's socio-economic profile
   (ii) Transport system in the State
6. **Traffic Surveys (See Section 6)**
   (i) Study of data from records
   (ii) Traffic counts, O-D. Surveys, etc
   (iii) Traffic projections
   (iv) Collection of traffic particulars for railway level crossings and road junctions
   (v) Axle load surveys
   (vi) Analysis of accident records
7. **Soil and Materials Surveys (See Section 12)**
   (i) Study of available information
   (ii) Soil investigations for low embankments and demarcation of borrow areas
   (iii) Special investigations for high embankment
   (iv) Detailed investigations for flexible pavement/rigid pavement
   (v) Survey and evaluation of naturally occurring aggregates
   (vi) Manufactured aggregates/items
   (vii) Water for construction purposes
8. **Drainage Studies (See Section 15)**
   (i) HFL and ponded water level
   (ii) Depth of sub-soil water table
   (iii) Special investigations for cut sections and seepage glows
   (iv) Surface run-off
9. **Cross-drainage Structures (See Section 15)**

(i) Site selection

(ii) Collection of hydraulic and foundation data

Appendix-5
(Ref. paras 9.2.1 & 9.5.4)

RECOMMENDED MITIGATING MEASURES AND SUGGESTED GRADINGS FOR INITIAL ENVIRONMENTAL EXAMINATION (IEE)

(Clause 9.2.1)

ACTIONS AFFECTING ENVIRONMENTAL RESOURCES AND VALUES		RECOMMENDED FEASIBLE MITTING MEASURES	EE GRADI-NG (SUGGT-ESTIVE)
(a)	**Envinmental Impacts Due to Project Location**		
	(i) Disruption to hydrology	May be avoided through planning measures	D2
	(ii) Resettlement	Suitable compensation and resettlement planning require consideration	D1
	(iii) Environmental aesthetics degradation	Care shall be taken to avoid/minimise effect	D2
	(iv) Inequitable locations for rural roads	Cross roads suitably clubbed for access to the road. For the purpose, suitable connectors to be planned as part of project	D3
	(v) Loss of terrestrial ecology including forests and widlife	May be avoided through planning exercise or minimise the effect with mitigation measures	D2
	(vi) Loss of swamp ecology	May be avoided through planning exercise or minimise the effect with mitigation measures	D2
(b)	**Impacts During Construction Phase**		
	(i) Site runoff from cut and fill area	Suitable measures to be adopted during construction	D1
	(ii) Safety of works from accidents	All safety measures may be incorporated in tender document	D1
	(iii) Slum creation hazards	Appropriate planning for housing of construction workers must be made	D1
	(iv) Cultural differences hazards	Should preferably be avoided and public learning be made and considered	
	(v) Escape of hazardous materials	Strict monitoring the movement of hazardous materials	D2
	(vi) Escape of air pollution (including dusts)	Suitable measures will be adopted to prevent/ minimise	D1
	(vii) Noise and vibrations	Effect shall be assessed and measures taken based on significance	D1
	(viii) Quarrying hazards (including use of explosives)	Appropriate planning operation of blasting and use of operating quarries	D3

ACTIONS AFFECTING ENVIRONMENTAL RESOURCES AND VALUES	RECOMMENDED FEASIBLE MITTING MEASURES	EE GRADI-NG (SUGG-ESTIVE)
(ix) Disruption of utilities along route	Shifting of utilisies shall be planned in advance and provision kept in the project	D2
(x) Disruption of traffic along route	Judiciously planned to avoid/minimise disruption	D1
(c) Impacts from Project Operations		
(i) Noise disturbances	Shall not go up from present level	D1
(ii) Vibration disturbances	Appropriate planning and post-construction monitoring may be made	D1
(iii) Air pollution	Appropriate planning and post-construction monitoring may be made	D1
(iv) Continuing erosion	Protective vegetation and other medhods shall be adopted	D2
(v) Highway runoff contamination	Appropriate planning and post-construction monitoring to take care	D2
(vi) Highway spills of hazardous materials	Appropriate spills control program and post-construction monitoring to take care	D1
(vii) Escape of sanitary wastes	Appropriate planning/post-construction monitoring to be considered	D1
(viii) Congestion at access/exit points	Appropriate planning/post-construction monitoring be made to reduce/eliminate the effect	D2
(ix) Inadequate highway maintenance	Post-construction monitoring is recommended	D3

Note: IEE grading Scale:

D1-Not significant
D2 -Small significant effect
D3-Moderate significant effect
D-4 Major significant effect

Appendix-6
(Ref. para 10.14)

CHECK LIST FOR A HIGHWAY PROJECT FEASIBILITY REPORT

1. FEASIBILITY REPORT

1.1. Executive Summary

1.2. Economic and social setting

(i) State's economic profile, including GDP, agricultural production, industrial output, mining, etc. and their growth rates

(ii) State's population and growth rates

(iii) Potential of industrial and other economic growth in the project influence area

1.3. Transport system of the State

(i) Main transport modes and their extent

(ii) Road network in km by classification, carriageway width and surface type

(iii) Vehicle fleet and its growth

(iv) Annual expenditure on roads (original works and maintenance) by road class

(v) Annual road taxes (State and Central)

(vi) Profile of road transport industry

(vii) Road maintenance norms and allotments

(viii) Road accident statistics

(ix) Consumption of petrol and diesel and growth trend

1.4. Organisational structure of P.W.D./Highway Department

1.5. Socio-economic profile of the project area

1.6. Project description

(i) Scope

(ii) Necessity

(iii) Source of funding and budget provision

(iv) Selection of route

(v) Management

(vi) Alignment

(vii) Cross-sectional elements

(viii) Drainage facilities

(ix) Construction technology

1.7. Methodology adopted for the studies

(i) Division into homogenous sections

(ii) Traffic studies like classified counts, Origin-Destination, Axle Load Survey

(iii) Traffic growth rates

(iv) Road inventory, including roughness data

(v) Survey and investigation results

- Soil surveys
- Material survey
- Pavement deflection data
- Design of cross-drainage works

1.8. **Design, Report**

(i) Project road inventary

(ii) Engineering survey and investigation data

(iii) Design standards and specifications

(iv) Special site conditions effecting design

(v) Pavement design

(vi) Design of cross-drainage and other structures

1.9. **Cost estimates**

(i) Item rates and rate analysis

(ii) Escalation

1.10. **Construction programming**

1.11. **Economic analysis**

(i) Vehicle operating costs

(ii) Time costs

(iii) Accident costs

(iv) Economic costs and benefits

(v) Shadow pricing

(vi) Sensitivity analysis

(vii) Discussion of results

1.12. **Construction arrangements**

(i) Prequalification procedure

(ii) Bidding procedure

(iii) Supervision arrangements

1.13. **Conclusions and recommendation**

2. **DRAWINGS:**

(i) Locality map

(ii) Plans showing various alternative alignments considered and the selected alignment

(iii) L-sections of the selected alignment

(iv) Typical cross-sections showing pavement details

(v) Strip plan

(vi) Drawing showing cross drainage and other structures

(vii) Road junction plans

(viii) Roadways land acquisition plan

Appendix-7
(Ref. para 14.1)

INVENTORY & CONDITION SURVEY FOR BRIDGES

Sheet No.

Road Name :

Section :

Road No. :

Date of Survey :

Sl. No.	Location (km)	Name of River and Type of Crossing	Length of Bridge/Span Arrangement (m)	Average Vertical Clearance (m)	Type of Bridge			Year of Construction	Details of Superstructure			HFL (m)	Thickness of Girder/ Slab (m)	Type of Protection Work and Condition	Remarks
					Super-structure	sub-structure	Found-ation		Features	Type	Condition (VG/G/F/P/VP)				
									Deck Carriageway Footway Ralling						
									Deck Carriageway Footway Ralling						
									Deck Carriageway Footway Railling						

Note : VG=Very Good G=Good P= Poor VP= Very Poor

Surveyed by :.....

INVENTORY & CONDITION SURVEY FOR CULVERTS

Sheet No.

Road Name :

Road No. :

Section :

Date of Survey :

Sl. No.	Location (km)	Type of Structures (Pipe, Slab Box, Arch)	Thick-ness of Slab (m)	Span Arrange-ment and Total Ventway (No.x Length) (m)	Carriage-way Width (m)	Width of Culvert (m)	Details of Protection Works		Condition of various features of Culvert					Height above Bed Level		Presence of Scour	Adeq-uacy of Water-way	Remarks
							Type	Condition	Slab/Pipe-Box Arch	Head wall	Wing Wall	Return wall	Parapet/Handrail	U/S Side (m)	D/S Side (m)			

Note: G = Good F= Full P= Poor VP=Very Poor NA= Not Avoidable Surveyed by .....

PAVEMENT CONDITION SURVEY

Sheet No.

Road Name :

Road No. :

Section (FROM) : To

Date of Survey :

To

Weather :

District (FROM) :

CHAINAGE		Pavement Composition			Shoulder		Riding Quality		Pavement Condition					Pavement Edge drop	Embankment Condition	Road side Drain	Remarks
From (km)	To (km)	Composition	Type*	Thickness (mm)	Composition	Condition (Fair/Poor/ Falled)	Speed (km/hr)	Quality G/F/P/ VP)	Cracking (%)	Ravelling (%)	Potholing (No. and % 100m)**	Rut (None/Mod-erate/Sevare)	Patching (No. and (%100m)**	(mm)	(Good/Fair/ Poor)	(NE/PF/ F)***	
		Surface															
		Binder															
		Base															
		Sub-base															
		Subgrade															
		Surface															
		Binder															
		Base															
		Sub-base															
		Subgrade															

Note: * : BUSG= Built up Spray Grout; AC= Asphaltic Concrete; SDC= Semi Dense Concrete; PC= Premix Carpet; MSS= Mix Seal Surfacing WBM=Water Bound Macadam; DBM=Dense Bituminous Macadam; BM=Bituminous Macadam; BS= Brick Sollng; SS= Stone Sollng

** : No. and %/100m=Total no. of Potholing/Patching and % age area of Potholing/Patching 100m of length of road

*** : NE= Non Existing; PF=Partially Functional; F=Functional

Surveyed By:.....

ROAD IVENTORY DATA SHEET

Sheet No.

Road Name

Road No. :

Section (FROM) (km):

Road Classification :

To

Date of Survey :

From Km	To	Terrain (Plain/ Rolling/ Hilly)	Land Use (Built Up/ Agrt./Forest/ Industrial/ Barren)	Name of Village/ Town	Form-ation Width (m)	CARRIAGEWAY Type* (BT/CC/ GR/ER)	CARRIAGEWAY Width (m)	CARRIAGEWAY Condi-tion** (G/F/ P/VP)	SHOULDER+ Type* (BT/CC/ GR/ER)	SHOULDER+ Width (m)	Cond-tion** (G/F/ P/VP)	Embank-ment Height (m)	Submer-gence (cm)	Details of Cross Roads Location (km)	Details of Cross Roads Road No. (km)	Details of Cross Roads Carriage-way Width (m)	Remarks

NOTE: TYPE*: BT=Bituminous CC=Cement Concrete GR=Gravel ER=Earthen

CONDITIOIN: G=Good F=Fair P=Poor VP=Very Poor

+ Information about left and right shoulder's if of different nature, may be according recorded.

Surveyed by:.....

Name of the Project _____

BRIDGE INVENTORY

BRIDGE NO.	LOCATION (Km.)	NAME OF RIVER BRIDGE	YEAR OF CONSTRUCTION	NUMBER OF SPANS	SPAN ARRANGEMENT (EXPANSION JOINT TO ENPANSION JOINT) (m)	CLEAR SPANS	LENGTH OF BRIDGE FACE TO FACE OF ABUTMENTS (m)	HIGH LEVEL OR SUBMISSIBLE	CLEAR ROAD WAY WIDTH BETWEEN KERBS (m)	TOTAL OUTER WIDTH OF BRIDGE (m)	WIDTH OF FOOTPATH (m)	SUPER STRUCTURE						DETAILS OF WEARING COAT		SUB-STRUCTURE					
																					THICKNESS ON PIER (m)			MATERIALS USED	
												GRADIENT	TYPE	TYPE OF BEARING	THICKNESS OF SLAB (m)	MATERIAL OF SLAB	HANDRAILPARAPET THICKNESS & HEIGHT (m)	TYPE	THICKNESS (m)	TYPE	TOP	BOTTOM	HEIGHT OF PIER & ABUTMENT (m)	ABUTMENT	PIER
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27

PIER FOUNDATION		ABUTMENT FOUNDATION		PROTECTION WORK						PRESENT CONDITION OF BRIDGE												
TYPE	MATERIAL	TYPE	MATERIAL	BED	APPROACH	SKEW ANGLE (Degree)	VERTICAL CLEARANCE (BELOW BOTTOM OF DECK SLAB) (m)	ROAD FORMATION LEVEL (m)	DIRECTION OF FLOW	ABUTMENTS	PIERS	SLAB	BEARINGS	PARAPET	CLEAR WATER WAY (m)	DESIGN OF LOADING	HIGH FLOOD LEVEL (H.F.L.)	LOWEST WATER LEVEL (L.W.L.)	DESIGN DISCHARGE (Cu.m.)	MAXIMUM DESIGN VELOCITY (m/sec.)	REMARKS	
28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	

ROUGHNESS MEASUREMENTS USING BUMP INTEGRATOR

Chainage Km.	Direction 1				Direction 2				Mean Value (A+B) 2 cm/km
	Bump Reading B R	Wheel Revolution W R	Road Condition (Type of Surface Thickness, Drainage, etc.)	UI cm/km A	Bump Reading B R	Wheel Revolution W R	Road Condition (Type of Surface Thickness, Drainage etc.)	UI cm/km B	

INTRODUCTION OF COMPUTER BASED ROAD DATA BANK

1. Introduction

The advance of personal computers desk top, lap top or palmtop has made it possible to establish road data banks which can be used both for macro and micro level administration of various road networks.

As far as possible all project preparation work shall be made computer oriented and the basic steps starting from collection of data on Road Inventory, condition survey etc. shall be formulated with due consideration to the requirement of computer based Road Data Bank (RDB).

The important element in establishment of an RDB is the choice of reference system. The reference system for the National and State Highways may be the kilometer posts. For secondary road system the same may be tied to the NH & SH road networks. Hence, prior to collection of data the reference system has to be determined to suit the application of data for easy storage and retrieval.

2. Role of Computer-aided Design

The rapid development of computer packages in recent years has transformed the highway and junction design process. No longer do large numbers of repetitive calculations have to be laboriously carried out by hand. Instead increasingly powerful and compact computers, together with increasingly sophisticated and commercially available software packages, which now include computer graphics, make it possible to investigate a greater number of design options, and to undertake the necessary design calculations more reliably and in a much shorter period of time.

Furthermore, the development of computer graphics programs can be of considerable help to decision-makers since a picture or diagram can often replace many words and numerical tables, and get over a message or impact in a much more satisfactory and clear-cut way.

Computer-aided design (CAD) packages have a number of important roles to play.

(a) Because they enable repetitive calculations to be carried out quickly and accurately, the designer can investigate a wide range of possible solutions and determine their consequences.

(b) It follows from the above that any modifications to a particular scheme involving recalculations can also be easily and quickly carried out.

(c) Computer package are capable of storing considerable valumes of design data. These can be readify recalled if necessary. Furthermore, if any design modifications are carried out, the new information goes into the memory and replaces the original information. Three advantages follow from this:

(i) the information in the memory store is always up-to-date;

(ii) information on various aspects of a design, such as, horizontal and vartical alignment calculations, drainage alignment details including inlet and manhole locations, lighting column positions, details of public utility services runs and depths are stored, and so any potential design conflicts can be identified by retrieving and plotting from appropriate data sets (e.g. lighting column coincident with a draignage pipe, or inadequate clearance under a bridge after adjusting the road vertical alignment);

(iii) all the information can be stored centrally, but accessed from remote terminals, including any on the construction site.

(d) The visual appearance of a scheme can be determined from a wide range of viewing positions. Normally the proposed scheme is set against the developmental background in order that an assessment can be made of the visual impact (if any) on the local area. It is also possible to assess the extent to which landscaping and planting will reduce the visual intrusion.

Many commercial design packages are now available in this country for determining the best alignment for a length of roads.

3. What is CAD

When using any design package it is important to realise its limitations. For example, although the computer can carry out calculations rapidly and accurately, it can only do these in the way specified within the program. It cannot be creative nor can it usually take decisions except in very simple situations. What it can do, however, is to provide information as an input into the decision-making process. This information will often include not only numerical comparisons between alternative schemes, such as capital cost, but also subjective comparisons, such as the extent of visual intrusion.

In all computer applications it is important to know precisely the analytical basis of the design program, and its limitations. It should be remembered that the onus of interpreting any outpus always lies with the designer using the program.

When using any CAD packages it is important to ensure that all the input information is soundly based and up-to-date. This will range from information on site conditions, such as, locations and types of property, existing accesses, topographic information and existing road and junction layout details (since these impose possible constraints on what proposals might be developed) to the design year trafic flow predictions. If the input data are inaccurate or unreliable, then the outputs will also be poor, and this can lead to sub-optimal layouts being produced and adopted.

A CAD system will normally consists of the four main components as below:

(a) Input devices

(b) Processor

(c) Data Storage

(d) Output Devices

A single computer can either operate in isolation or be linked to other computers via a modern or the normal telecommunications network. These linkage can be within the same office, or with outside locations. This enables information and drawings to be transmitted quickly without the necessity of physical moving large amounts of paper.

4. Data Input Requirements

Highway design CAD programs and packages can be considered under two broad heading-junction design and road alignment design. Some CAD packages deal only with one or other of the above design areas, but more comprehensive interactive packages, embrace both.

5. Essential Compatible Requirements

To utilise the speed and accuracy of any electronic data processing system through use of sophisticated computer hardware's and software packages, it is necessary to modernise the data capturing from field/site and down loading the same direct to the computer. Any manual intput will slow down the process and may involve error. Use of survey equipment such as Total Station, Eletronic Theodolite, Electronic Distance Measurement (EDM), Autolevel, etc. are a necessity of the day to expenditiously complete a road project to meet the requirements of high international quality project preparation.

CHECK LIST OF ITEMS FOR DETAILED PROJECT REPORT FOR A HIGHWAY

1. PROJECT REPORT

1.1. Preliminary

(i) Name of work and its scope

(ii) Authority and plan provision

(iii) History, geography, climate, etc.

(iv) Necessity

(v) Economic profile or region and road influence area

1.2. Road Features

(i) Route selection

(ii) Alignment

(iii) Environmental factors

(iv) Cross-section elements

(v) Traffic studies and projection

1.3. Road Design and Specification

(i) Road design

(ii) Pavement design

(iii) Masonry works

(iv) Specifications

1.4. Drainage Facilities including Cross-Drainage Structures

(i) General drainage condition, HFL, Water-table, seepage flows

(ii) Surface drainage, catch water drains, longitudinal side drains

(iii) Sub-Surface drainage, blanket courses, sub-drains.

(iv) Cross-drainage structures

1.5. Material, Labour and Equipment

(i) Sources of construction materials, transport arrangements

(ii) Labour, availability, amenities

(iii) Equipment

1.6. Rates

(i) Schedule of rates

(ii) Rate justification

1.7. Construction Programming

(i) Working season and periods of low water level in rivers and canals

(ii) Schedule of completing the work

1.8. Miscellaneous Items

(i) Rest houses, temporary quarters

(ii) Diversion and haul roads

(iii) Site amenities

(iv) Traffic control devices, etc.

(v) Roadside plantations, turfing, landscaping

2. **ESTIMATE**

(a) General abstract of cost

(b) Detailed estimates for each major head

(i) Abstract of cost

(ii) Estimates of quantities

(iii) Analysis of rates

(iv) Quarry/material source charts

3. **PROJECT DRAWINGS**

(i) Locality map-cum-site plan

(ii) Land acquisition plans

(iii) Drawings showing location of sources for construction materials

(iv) Plan and longitudinal section

(v) Typical cross-section sheet

(vi) Detailed cross-sections

(vii) Drawings for cross-drainage structures

(viii) Road junction drawings

(ix) Drawings for retaining walls and other structures

(x) Drawings of proposed wayside amenities

(xi) Drawings showing location of various road signs

LIST OF LABORATORY TESTS TO BE CONDUCTED FOR HIGHWAY EMBANKMENTS

A.10.1. BOREHOLE SAMPLES

1. TESTS ON UNDISTURBED SAMPLES

Undisturbed samples are those collected in 100 mm dia thin-walled tubes conforming to IS:2132-1972. These should be tested in the laboratory for the determination of the following soil properties :

(i) Grain size analysis (as per IS:2720 Part IV-1975)

(ii) Natural moisture content (as per IS:2720 Part II-1973) and dry density

(iii) LL & PL (as per IS:2720 Part V-1970)

(for soils suspected to be organic in nature, by virtue of colour, odour, texture, etc. LL on fresh as well as on oven-dry specimens may be separately found out)

(iv) c_s, c_v and p_c (preconsolidation pressure) from consolidation test (according to IS:2720 Part XV-1965)

(v) c and Ø from unconsolidated, undrained (UU) triaxial test (according to IS:2720 Part XI-1971). Bulk density, void ratio and moisture content before/after UU test should also be determined.

(vi) Shrinkage limit–free swell and swelling pressure (particularly in case of black-cotton soil) as per I.S.

2. TESTS ON SELECTED UNDISTURBED SAMPLES

Where the method of stage construction of embankment based on the effective stress method of design requires to be kept in view, selected and representative undisturbed samples should be further tested in the laboratory for the determination of the following soil properties :

c'/Ø' and A-factor from consolidated undrained triaxial tests with measurement of pore pressure i.e.C-U tests (according to IS:2720 Part XII-1981). Bulk density, void ratio and moisture content before/after C-U test should also be determined.

3. TESTS ON DISTURBED SAMPLES

Samples from test pits must be tested for the following tests. Samples recovered from the SPT spoon should be retained in sealed air-tight glass jars. These samples may be treated as disturbed samples and should be tested in the laboratory for the determination of following soil properties:

(i) Grain size analysis (according to IS:2720 Part IV-1975)

(ii) Natural moisture content (as per IS:2720 Part II-1973)

(iii) LL & PL (as per IS:2720 Part V-1970)

(For soils suspected to be organic in nature by virtue of colour, odour, texture, etc., LL on fresh as well as on oven-dry specimens may be separately found out).

A.10.2. ON FILL MATERIAL TO BE USED FOR FORMING HIGH EMBANKMENTS

2. Laboratory tests to be done

(a) Tests to be done on each sample

(i) Grain size analysis (as per IS:2720 Part-IV-1975)

(ii) Natural moisture content (as per IS:2720 Part-.II-1973)

(iii) LL and PL (as per IS:2720 Part-V-1970)

(For soil suspected to be organic in nature by virtue of colour, texture, odour, etc., LL on fresh as well as on oven-dry specimens may be separately found out)

(iv) Moisture-density relationship using light/heavy compaction, commonly known as Standard/modified proctor test (as per IS:2720 Part-VIII-1980)

On the basis of tests conducted as per (a) above, the samples may be categorised into types, each showing the same or closely similar soil characteristics. One or two samples out of each category may be judiciously selected so as to be representative and subjected to the following tests:

(i) For cohesive fill material (e.g. clay or silty/sandy clay mixed with silt/sand), c and Ø may be determined from unconsolidated undrained (UU) triaxial test (according to IS:2720 Part-XI-1972) on specimens remoulded to 95% proctor density at OMC plus 2%.

(ii) If the fill material is cohesionless, Ø may be determined from direct shear test (according to IS:2720 Part-XIII-1972) on specimens remoulded to 95% proctor density at OMC.

(iii) For cohesive fill materials which may be used for forming embankments likely to be subjected to submergence and drawdown, effective stress parameters c' and Ø' as also A-factor, may be determined from consolidated undrained test with measurement of pore pressure i.e. CU tests (according to IS:2720 Part-XII-1981) on specimens remoulded to 95% proctor density at OMC plus 2%. The test specimens in the triaxial cell need to be saturated by applying back pressure before shearing. This test will be in addition to that mentioned in (b) (i) above and may be carried out for selected few representative samples only.

(iv) For any of the types of strength tests mentioned above, the actual bulk density, void ratio and moisture content of the specimens before/after the test should be found out and recorded.

A. Salient Features of the MOEF Environment Guidelines for Highway Projects

1. **Purpose of Guidelines**

   (i) To assist the project authorities in planning and carrying out EIA and envolving Environmental Management Plan:

   (ii) These guidelines apply to both new projects and upgrading of existing facilities.

2. **Environmental Impact Assessment (EIA)**

   (i) EIA procedure identifies the possible positive and negative impacts resulting from a proposed project (Table A-11.1).

   (ii) For identification of impacts, Table A-11.2. are provides a list of parameters relevant to transportation project including roads. The parameters are classificed into four categories, viz., Natural physical resources, natural biological resource, human development resources and quality of life values including aesthetic and cultural values. See Table A-11.3. for questionnaire for environmental appraisal of project.

3. **Environmental Impact Statement (EIS)**

The EIS should cover

(i) Brief description of project
(ii) Description of existing environment with in project influence area
(iii) Likely impact; adverse and beneficial, reversible and irreversible
(iv) Mitigation, protection and enhancement measures
(v) Consideration of alternatives including "no change option"
(vi) Summary and conclusions

4. **Environmental Management Plan (EMP)**

It is an implementatioin plan for mitigation, protection and/or enhancement measures recommended in the EIS. It may include several implementation plans. Each should include;

(i) Objective
(ii) Work plan for Design criteria
(iii) Implementation schedule
(iv) Manpower requirements and
(v) Monitoring.

5. **Identification of Impacts**

   (i) Physical Resources
   Impacts on hydrology, surface water quality, air quality, soils and noise impacts.

   (ii) Econogical Resources
   Impacts on fisheries, forestry, wild life, ecosystems.

   (iii) Human use Values
   Impacts on navigatioin, flood control, land-use.

   (iv) Quality of life Values
   Impacts on socio-economic aspects, resettlement issues, public health, aesthetics, historical value.

6. **Measures for Mitigation of Adverse Impacts**

Careful attention be paid to site planning to minimise adverse impact to the extent possible. Protection measures may include establishment of forest reserve to minimise encroachment, fencing of road land, promoting new rural occupations.

Measures to deal with the various impacts are outlifed as under:

(i) **Air Quality:** Mobile source emissions.

- Construction during off-peak hours in heavy traffic areas
- Use of low emission construction vehicles

- Periodic check on all vehicles for emission control
- Use of lead free gasoline.

(ii) **Air Quality:** Fixed Source Emissions

- Stationary equiment to be located as far away as possible from the receptors
- Areas prone to dust emissions be sprinkled with water
- Dust covers over the beds of trucks
- Low emission equipment for construction

(iii) **Noise:** Construction period

- Specify permissible standards for noise for construction equipment
- Specify maximum permisible noise levels in residential, commercial and institution areas
- Specify time restrictions in sensitive areas such as schools, hospitals
- Describe methods of enforcement for the above.

(iv) **Noise:** Operation Phase

- ROW to have buffer strip on each side of road and where possible tree belts be planted
- Nose insulation including noise barries in certain areas such as schools/hospital
- Rerouting heavy traffic
- Changing speed limits
- Changing alignment

(v) **Vibration**

- Appropriate construction technique to prevent damages due to vibration effects during construction.

(vi) **Relocation**

- Adequate time be given to relocatee to find suibable alternative place
- Public relations through media
- Advance payment to relocatees
- Compensation for land property should be based on fair market value
- Reestablishment cost be carefully considered to off set the loss in income, increase in expenditure and relocatees may be offered replacement of living unit organised by the project authorities.
- Special low cost housing for squatters
- Set up special work sub-section to follow up the problems faced by the relocatees

7. **Environmental Monitoring**

(i) **Air Monitoring**

Monitoring stations for air quality are recommended along the project road to compare with the background data parameter to be monitored are CO, HC, SO2, NOx and Pb. Frequency and duration of sampling may be sorted out with the concerned meteorological departments.

(ii) **Noise Monitoring**

Monitoring of lead (Pb) content in the nearby water bodies and plants is recommended. Locations be determined in consultation with the Pollution Control Boards.

(iii) **Water Quality Monitoring**

Monitoring Sations be set-up in consultation with the Pollution Control Board of the Centre/State.

8. Management Considerations

- Cut and fill technology
- Treatment of unstable areas
- Vegetative cover on slopes. Plant species in consultatioin with forest department
- Erosion control measures
- Careful attention to drainage needs
- Channel training and erosion control works of culverts
- Controlled blasting of rock
- Excavated material should not be dumped haphazardly
- Provisioin of adequate protective works
- Adequate provision of water supply, power and sanitation facilities.

Note: Vide MOEF letter No. J-21012/15/96-IA-III dated 12 March, 1997, the MOEF wrote to Secretary Ministry of Surface Transport regarding recommendations of the Working Graph constituted to consider issues relating to exemption from environmental clearance for road projects along existing alignments.

A. Recommendations are

(i) Projects for improvement works along existing alignments with marginal land acquisition be exempted from environmental clearance.

(ii) Cases involving acquisition of marginal land would be examined by the concerned Ministry and approval accorded at their end, keeping in view the following:

(a) No problems envisaged where land is in possession of the department

(b) No problems envisaged where extra barren land is to be acquired

(c) Adequate compensating plantation necessary where acquisition of additional land involves cutting of trees

(d) Where acquisition of additional land involve, displacement of locals

(iii) Where diversion of forest land is involved, clearance would be required under the forest (conservation) Act 1980

(iv) Where the road passes through ecologically sensitive area such as sanctuaries tiger reserve, reserved forests, environmental clearance is essential

(v) It is necessary for project proponents to carry out EIA study and provide mitigative measures

(vi) MOEF would be kept apprised of any developmental projects being implemented.

B. Coastal Regulation Zone

Coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters which are influenced by tidal action (in the landward side) upto 500 meters from the High Tide Level (HTL) and the land between the Low Tide Level and the HTL is declared as Coastal Regulation Zone.

Construction activities are prohibited in the Coastal Regulation Zone except for existing roads or those specifically approved in the Coastal Zone Management Plan of the area categorised as CRZ II, viz., the areas that have already been developed upto or close to the shore line and provided inter-alia with approach road.

Table-A-11.1

Beneficial and Negative Impacts of Highway Projects

BENEFICIAL IMPACTS	NEGATIVE IMPACTS
Employment opportunity to people	Erosion and sediment dischage.
Enhancement of local industry, agriculture and handicrafts	Poor drainage resulting in rail/road/highway demage and leading to flooding problems and degradation of water resources. Formation of new gullies.
Income from visitors and taxes	
Enhancement of rural development through quick and easy transportation of building materials.	Increase in concentration of runoff causing surface water pollution.
Transporting, processing and marketing of agricultural products.	Clearing of roadside vegetation for fire-wood, grazing, cultivation and urbanisation.
Opening up of opportunities for new occupations.	Increase in traffic litter, noise and dust.pollution.
Approach to quick services and safety.	Air quality affected by vehiclular exhaust smoke with reference to SPM, NOx, CO, HC and lead.
Improved quality of life for people and so on.	Spell of toxic and hazardous chemicals from the carriers using the highway for transportation of such material. Transfer of vector diseases.
	Effect on wildlife through habitat loss and encroachment.

Table-A-11.2

Some Environmental Parameters Associated with Transportation Sector Projects

Developmental Projects	Environmental Parameters
Highway	Surface water quality
	Air Quality
	Siesmology/Geology
	Erosion
	Land Quality
	Fisheries
	Forests
	Terrestrial Widlife
	Noise
	Land use
	Aesthetics
	Industries
	Resettlement
	Archaeological/Historic
	Significance
	Public Health
	Socio-Economic

B. Cost of environmental protection measures (Rs. Lakhs)

S.No.		Recurring Cost per annum	Capital Cost
1.	Pollution Control		
2.	Pollution Monitoring		
3.	Solid Waste Management		
4.	Green Belt		
5.	Others (Please Specify)		
	Total		

XXXII. Public Hearing

A. Date of Advertisement
B. Newspapers in which the advertisement appeared
C. Date of Hearing
D. Panel Present
E. List of Public present along with addresses and occupation

S.No.	Summary/details of public hearing Issues raised	Recommendation of panel	Response of Project Proponents
1.			
2.			
3.			
4.			

The data and information given in this Performa are true to the best of my knowledge and belief

Date :

Signature of the Applicant with full name & address.

Place:

Given under the seal of organisation on behalf of whom the applicant is signing.

Table-A-11.3

Questionnaire for Environmental Appraisal
(For Road/Highway Projects)

Note 1. :	All information given in the form of annexures should be part of this file itself. Annexures as separate files will not be accepted.
Note 2. :	Please enter x is appropriate box where answer is Yes/No

I. General Information

A. Name of the project

B. Length (in kilometres)

C. Location

Stretch of Road/Alignment	Village	Tehsil	District	State

D. Geographical information

1. Latitude From [ ] To [ ]
2. Longitude From [ ] To [ ]
3. G.T. Sheet No. (Survey of India Map No.). [ ]
4. Elevation above Mean Seal Level (metres)

   Min. [ ] Max. [ ]
5. Total Area proposed for the Project (in ha.) [ ]
6. Nature of Terrian

7. Nature of Soil (Clayey, Sandy, Silty, Loam, etc.)

8. Permeability along the route in varius Sections

II. Current land use of the proposed project site area (in ha.)

A. Agricultural

1. Irrigated

2. Unirrigated

B. Homestead

C. Forest

D. Notified Industrial Area/Estate

E. Grazing

F. Fallow

G. Mangroves

H. Orchards

I. Sand Dunes

J. No Development Zone

K. Marshes

L. National Park/Sanctuary

Total

III. Alternate Routes/Aligments Considered

A. _____

B. _____

C. _____

D. _____

IV. Reason for selecting the proposed Route/Alignment:

V. Land use plan

A. Does the proposed project conform to the approved land use all along the route/alignment? (To be certified by the concerned Department of State Government).

Yes ☐ No ☐

B. If not, clearly indicated, which of the stretches are not as per approved land use.

C. Does it conform to the Regional Development Plan?

Yes ☐ No ☐

VI. Site Preparation

A. Is the proposed route/alignment located in low-lying area?

Yes ☐ No ☐

B. Level before filling (above MSL in m)

C. Level after filling (above MSL in m)

D. Details of fill material required

Quantity of Fill Material required (in cu.m)	Source

E. **Gradient details**

F. **Would be above filling result in complete/partial filling of water Bodies?**

G. **Does the site involve stripping?**

Yes ☐ No ☐

If yes, provide the following details:

1. Size of the area to be stripped.
2. Location
3. Soil type
4. Valume and quantity of earth to be removed
5. Location of dump site
6. Proposal for utilisation of removed top soil.

H. **Does it involve cutting?**

Yes ☐ No ☐

If yes, please furnish the following details:

1. Size of the area to be cut
2. Depth of cut
3. Location
4. Soil type
5. Volume and quantity of earth and other material to be removed
6. Location of dump site.

I. **Does it involve tunneling?**

Yes ☐ No ☐

If yes, please furnish the following details:

1. Lithology
2. Geological structural fraction
3. Diameter (meters)
4. Length (kilometer)
5. Location

J. Does the site preparation require cutting of trees?

Yes ☐ No ☐

If yes, please furnish the following details:

1. How many trees are proposed to be cut?
2. Species of the above trees
3. Are there any protected/endangered species?

Yes ☐ No ☐

If yes, provide details

VII. In case the route/alignment falls totally or partially in the CRZ area

A. What is the categorization of the area (as per approved CZMP)?

CRZ-I ☐ CRZ-II ☐ CRZ-III ☐

CRZ-IV ☐

B. Does the proposed activity quality under the category of permissible activity?

Yes ☐ No ☐

C. If yes, under what provision is it permitted?

SI. No.	Provision No.

D. In case the road passes through a flood plain of a river, please furnish:

1. Detailed micro-drainage
2. Flood passages
3. Flood periodicity in the area

E. Does the proposed project involve construction on any sandy stretch?

Yes ☐ No ☐

If yes, please furnish detail

F. Height (above MSL in metres). ☐

G. Does the project involve extraction of sand, leveling or digging of sandy stretches within 500 mts. of high tide line?

Yes ☐ No ☐

If yes, mention the acitivity involved and area.

1. Stretch ☐
2. Area (sq. metres) ☐

H. Does the project involve any dredging?

Yes ☐ No ☐

If yes, please provide the following details (capital/maintenance):

Extent of dredging, disposal of dredged material etc.

I. Is any sand proposed to be removed from sand dunes?

Yes ☐ No ☐

J. Does the project invalue cutting/destroying of mangroves?

Yes ☐ No ☐

If yes, give detail

1. Area
2. Species
3. Existing health

VIII. Details of the location:

	Sea	Other Water Bodies River/Creek/Lake, etc. (Please specify)
Distance of seaward boundary from the edge of the alignment (in m.)		
Distance of seaward boundary of construction (in m.)		

IX. Does the proposed project site involve any breeding or nesting ground?

Yes ☐ No ☐

If yes, provide the following details

A. Name of the aquatic organism

B. Type of habitat

C. Period of year in which activity takes place

D. Independent report of biohabitat study may be furnished.

X. **Does the project have any adverse effect on biodiversity?**

If so, details of flora and fauna so affected:

XI. **Does the project involve any land reclamation?**

Yes ☐ No ☐

If yes, please provide the following details

A. Activity for which land to the reclaimed ☐

B. Area of land to be reclaimed (Hectares) ☐

XII. **Whether there will be any change in the drainage pattern after the proposed activity?**

Yes ☐ No ☐

If yes, what are the changes?

A. What is the maximum extent ☐

B. Is any additional area to be flooded ☐

XIII. Does the proposed alignment/route involve migratory path of animals?

Yes ☐ No ☐

If yes, please provide the following:

A. Name of fauna

B. Habitat

C. Period of the year in which activity take place

XIV. Project Details (A summary of project proposal shall be enclosed).

A.	Length of New alignment proposed (kms)		
B.	Width of the new alignment (meters)		
C.	Length of existing alignment proposed to be Strengthened/widened (kilometres)		
D.	Width of the existing alignment (metres)		
E.	Width of the existing alignment after widening (metres)		
F.	Total length of the alignment (kilometres)		
G.	No. of Bridges	Major	
		Minor	
H.	Length of Bridges (metres)		
I.	Width of Bridges (metres)		
J.	No. of Culverts		
K.	Length of Culverts (metres)		

L. Number and distance (metres) between underpasses

M. No. of intersections

N. Length of Intersection (metres)

O. No. of Railway crossings

P. Length of Railway crossings (metres)

Q. No. of Villages through which alignment passes through

R. Population of the villages

XV. Raw material required during construction

S.No.	Item	Quantity (Tonnes)	Mode of Transport	Source
1.	Stonemetal			
2.	Bricks			
3.	Sand			
4.	Cement			
5.	Bitumen			
6.	Diesel			
7.	Others (Please specity)			

XVI. Water required during construction:

A. Water Requirements (cu.m./day)

S. No.	Purpose	Average Demand	Peak Demand	Source	Type Treated/ Untreated/Fresh/ Recycled	Remarks
1.	Road making					
2.	Dust Suppression					
3.	Drinking					
4.	Others (Please specify)					
	TOTAL					

B. Source of Raw Water Supply (Net)

S.No.	Source	Cu.m/hr	Cu.m/day
1.	Sea		
2.	River		
3.	Groundwater		
4.	Rainwater harvesting		
5.	Municipal water supply		
6.	Others (Please specify)		

XVII. Whether there will be any ingress of saline water into ground water due to project?

Yes ☐ No ☐

XVIII. Whether any of the following exist within 7 km of the project site. If so please indicate aerial and the name of the site.

S.No.	Item	Name	Aerial Distance (in km)
1.	National Park		
2.	Marine Park		
3.	Sanctuary/Tiger Reserve/Elephant Reserve/Turtle westing ground		
4.	Core Zone of Biosphere Reserve		
5.	Reserved Forest		
6.	Widlife Habitat		

7.	Habitat of endagered/exotic species		
8.	Coral Reef		
9.	Mangroves		
10.	Lakes/Reservoirs/Dams		
11.	Breeding Site		
12.	Nesting Site		

XIV. Ambient Air Quality (for RPM, SPM, SO^2, NOX, CO)

Procedures adopted should be as per quidelines of CPCB and should cover one full season (Locations should be so selected to represent the varying geographical locations and sensitive receptors)

S.No.	Stretch of the road	Date, Time & Location	Concentration as monitored (in ug/m^3) SPM, SO^2, NOX, CO	Permissible Standard (As per SPCB guidelines	Remarks (Name of the instument and sensitivity)

XX. Solid Waste

A. Solid Waste generated during Road Construction (Tonnes/Day)

1. Top Soil

2. Overburden

3. Others (Please specify)

Total

B. Possible users of solid waste

C. Method of disposal of solid waste

Method	Quantity (TPM)
1. Landfill	
2. Others (Please specify)	
3. In case of landfill	

(a) Is solid suitable for landfill Yes ☐ No ☐

(b) Dimensions

(c) Life of landfill

(d) Proposed precautionary and mitigation measures

(e) Other alternative proposed along with details

XXI. Noise level (dB)

S.No.	Stretch of the Road (Locations should be so selected to represent the varying geographical locations and sensitive receptors)	Noise before Construction	Noise after Construction	Abatement Measures
1.				
2.				
3.				

XXII. Projected Air Quality (taking into account the traffic projections on this road). (SPM, SO^2, NOX, CO in ug/m^3)

S.No.	Pollutant	Before Constructions	After Construction
1.	SPM		
2.	SO^2		
3.	NOX		
4.	CO		

XXIII. Storage (of inflammable/explosive/hazardous/toxic substances)

S.No.	Name	Consumption (in TPD)	Maximum Quantity at any point of time (tonnes)	Means of trasnportation
1.	Bitumen			
2.	Diesel			
3.	Others (please specify)			

XXIV. Occupational Health

A. What are the major occupation health and safety hazards anticipated including due to use of explosive, if any?

B. What provision have been made/proposed to be made to conform to health/safety requirements?

C. Details of personal protective equipment provided/to be provided to the workers

XXV. Green Belt

A. Total area of project (in ha.)

B. Area already afforested (for existing projects), in ha.

C. Area proposed to be afforested (in ha.)

D. Width of green belt (minimum, in m.) along the alignment

E. Trees planted and proposed

Nos.

1. Planted
2. Proposed
3. List of species

F. Proposal for maintenance of plantation

XXVI. Construction Phase

A. Estimated duration of construction

B. Number of persons to be employed for construction

1. Peak
2. Average

C. Proposal for employment of local people

D. What provision has been made for the sanitation for the construction workers?

E. How the fuel (kerosene/wood, etc.) requirement of labour force will be met to avoid cutting of trees from the adjoining areas.

F. Measures for Health care will emphases on protection from endemic diseases.

XXVII. Socio-economic profile

A. Human Settlement

	Aerial distance from the periphery of the site		
	Upto 500 m From the Periphery	500 m to 3000 m From the Periphery	3000 m to 7000 m From the Periphery
Population			
Of which SC/ST			
Number of Houses			
Present Occupational Pattern			

B. Economic Activity

S.No.	Population	Occupation (Agriculture/Horticulture/Fishing/Tourism/Transport /construction)	Average Income per annum

XXVIII. Rehabilitation & Resettlement Plan including vocational training and other avenues of employment

A. Population to be displaced

S.No.	Name of Village	Population		
		Land oustees only	Homestead Oustees only	Land + Homestead Oustees
1.				
2.				
3.				

B. Rehabilitation Plan for Oustees

C. Site where the people are proposed to be resettled

D. Compensation package

E. Agency/Authority responsible for their resettlement.

XXIX. Does it involve displacement of ethnic minority

Yes ☐ No ☐

If yes, please furnish details

S.No.	Name of the community	Number of Males	Number of Females	Total

A. Please specify any special measures for their rehabilitation.

XXX. Pollution Control

A. Details of Pollution Control Measures/Environmental Safeguards:

S. No	Exisiting	Proposed to be installed
	1.	Air
	2.	Water
	3.	Noise
	4.	Solid Waste

B. Protection of Forest/National Park/Sanctuary/Mangroves

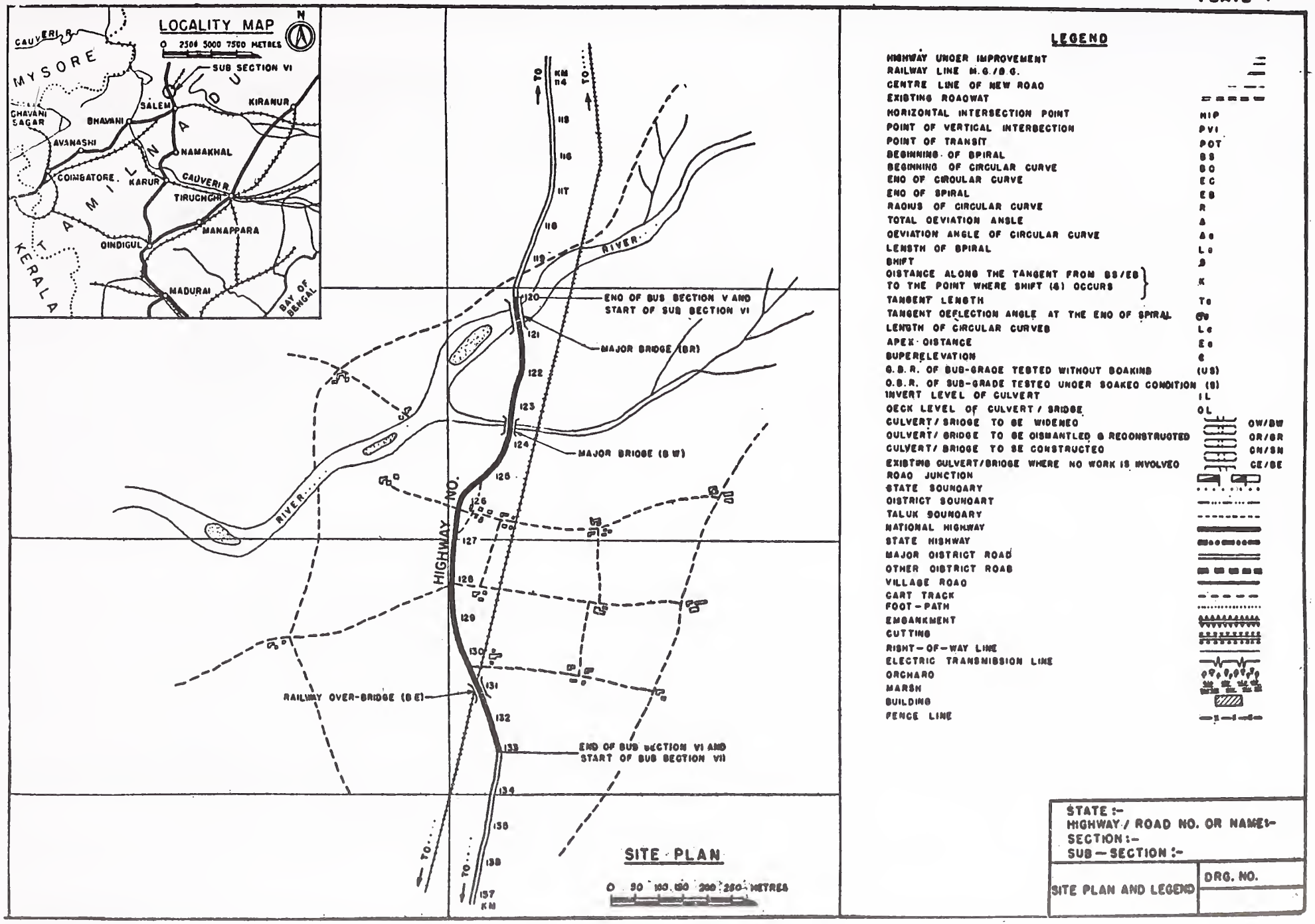
1. Agricultural land
2. Grazing land
3. Top soil
4. Natural resources
5. Sand dunes and mudflats
6. Hill feature
7. Reclaiming borrow areas
8. Low-lying area
9. Soil and slope stablization
10. Preventing siltation
11. Archaeological and other Heritage sites

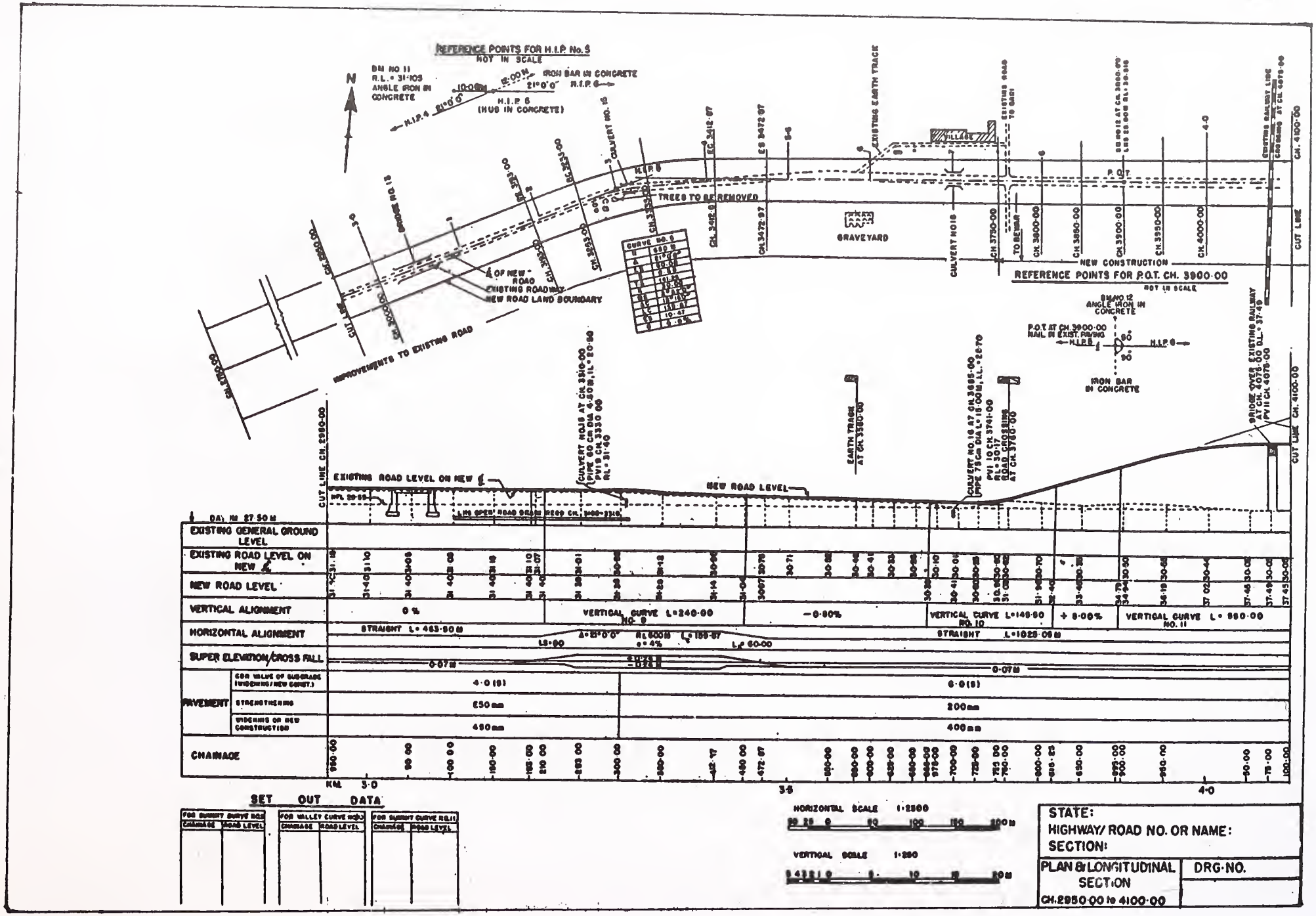
XXXI. Expenditure on Environmental Measures:

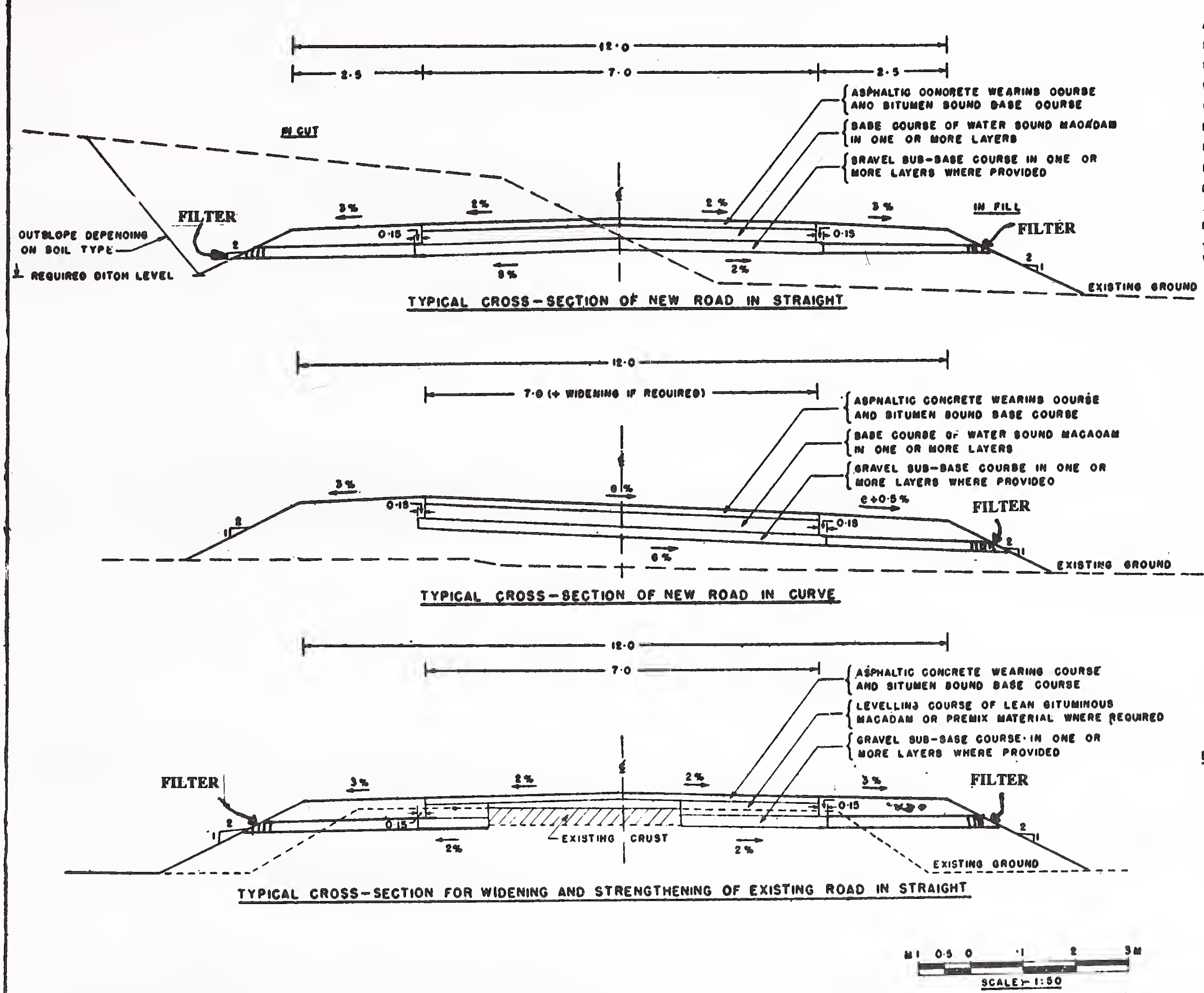
A. Capital cost of project (as proposed to the funding agency/financial institutions)

(Rs. Lakhs) [ ]

PLATE 1


LOCALITY MAP
0 2500 5000 7500 METRES
N
SUB SECTION VI
CAUVERI R.
MYSORE
CHAVANI SAGAR
BHAVANI
SALEM
KIRANUR
AVANASHI
NAMAKKAL
COIMBATORE
KARUR
CAUVERI R.
TIRUCHCHI
MANAPPARA
DINDIGUL
MADURAI
KERALA
BAY OF BENGAL
TO
KM 114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137 KM
RIVER
END OF SUB SECTION V AND START OF SUB SECTION VI
MAJOR BRIDGE (BR)
MAJOR BRIDGE (B W)
HIGHWAY NO.
RAILWAY OVER-BRIDGE (B E)
END OF SUB SECTION VI AND START OF SUB SECTION VII
SITE PLAN
0 50 100 150 200 250 METRES
LEGEND
HIGHWAY UNDER IMPROVEMENT
RAILWAY LINE M.G./B.G.
CENTRE LINE OF NEW ROAD
EXISTING ROADWAY
HORIZONTAL INTERSECTION POINT HIP
POINT OF VERTICAL INTERSECTION PVI
POINT OF TRANSIT POT
BEGINNING OF SPIRAL BS
BEGINNING OF CIRCULAR CURVE BC
END OF CIRCULAR CURVE EC
END OF SPIRAL ES
RADIUS OF CIRCULAR CURVE R
TOTAL DEVIATION ANGLE Δ
DEVIATION ANGLE OF CIRCULAR CURVE Δc
LENGTH OF SPIRAL Ls
SHIFT S
DISTANCE ALONG THE TANGENT FROM BS/ES TO THE POINT WHERE SHIFT (S) OCCURS K
TANGENT LENGTH Ts
TANGENT DEFLECTION ANGLE AT THE END OF SPIRAL δs
LENGTH OF CIRCULAR CURVES Lc
APEX DISTANCE Es
SUPERELEVATION e
C.B.R. OF SUB-GRADE TESTED WITHOUT SOAKING (US)
C.B.R. OF SUB-GRADE TESTED UNDER SOAKED CONDITION (S)
INVERT LEVEL OF CULVERT IL
DECK LEVEL OF CULVERT / BRIDGE OL
CULVERT / BRIDGE TO BE WIDENED OW/BW
CULVERT / BRIDGE TO BE DISMANTLED & RECONSTRUCTED OR/BR
CULVERT / BRIDGE TO BE CONSTRUCTED CN/BN
EXISTING CULVERT/BRIDGE WHERE NO WORK IS INVOLVED CE/BE
ROAD JUNCTION
STATE BOUNDARY
DISTRICT BOUNDARY
TALUK BOUNDARY
NATIONAL HIGHWAY
STATE HIGHWAY
MAJOR DISTRICT ROAD
OTHER DISTRICT ROAD
VILLAGE ROAD
CART TRACK
FOOT-PATH
EMBANKMENT
CUTTING
RIGHT-OF-WAY LINE
ELECTRIC TRANSMISSION LINE
ORCHARD
MARSH
BUILDING
FENCE LINE
STATE :-
HIGHWAY / ROAD NO. OR NAME :-
SECTION :-
SUB-SECTION :-
SITE PLAN AND LEGEND
DRG. NO.


REFERENCE POINTS FOR H.I.P. No. 5
NOT IN SCALE
BM NO 11
R.L. = 31·103
ANGLE IRON IN CONCRETE
IRON BAR IN CONCRETE
H.I.P. 5
(HUB IN CONCRETE)
N
TREES TO BE REMOVED
GRAVEYARD
EXISTING EARTH TRACK
CULVERT NO 16
NEW CONSTRUCTION
REFERENCE POINTS FOR P.O.T. CH. 3900·00
NOT IN SCALE
BM NO 12
ANGLE IRON IN CONCRETE
P.O.T. AT CH. 3900·00
NAIL IN EXIST. PAVING
IRON BAR IN CONCRETE
IMPROVEMENTS TO EXISTING ROAD
NEW ROAD LAND BOUNDARY
EXISTING ROADWAY
CUT LINE
CUT LINE CH. 4100·00
EXISTING ROAD LEVEL ON NEW
NEW ROAD LEVEL
EXISTING GENERAL GROUND LEVEL
EXISTING ROAD LEVEL ON NEW
NEW ROAD LEVEL
VERTICAL ALIGNMENT
VERTICAL CURVE L=240·00 NO. 9
VERTICAL CURVE L=140·00 NO. 10
VERTICAL CURVE L = 550·00 NO. 11
HORIZONTAL ALIGNMENT
STRAIGHT L = 463·50 M
STRAIGHT L=1025·06 M
SUPER ELEVATION/CROSS FALL
PAVEMENT
STRENGTHENING
WIDENING OR NEW CONSTRUCTION
CHAINAGE
KM. 3·0
3·5
4·0
SET OUT DATA
HORIZONTAL SCALE 1:2500
VERTICAL SCALE 1:250
STATE:
HIGHWAY/ ROAD NO. OR NAME:
SECTION:
PLAN & LONGITUDINAL SECTION
CH.2950·00 to 4100·00
DRG·NO.



TYPICAL CROSS-SECTION OF NEW ROAD IN STRAIGHT

TYPICAL CROSS-SECTION OF NEW ROAD IN CURVE

TYPICAL CROSS-SECTION FOR WIDENING AND STRENGTHENING OF EXISTING ROAD IN STRAIGHT

LEGEND FOR SYMBOLS APPEARING ON PLATES 3 & 4

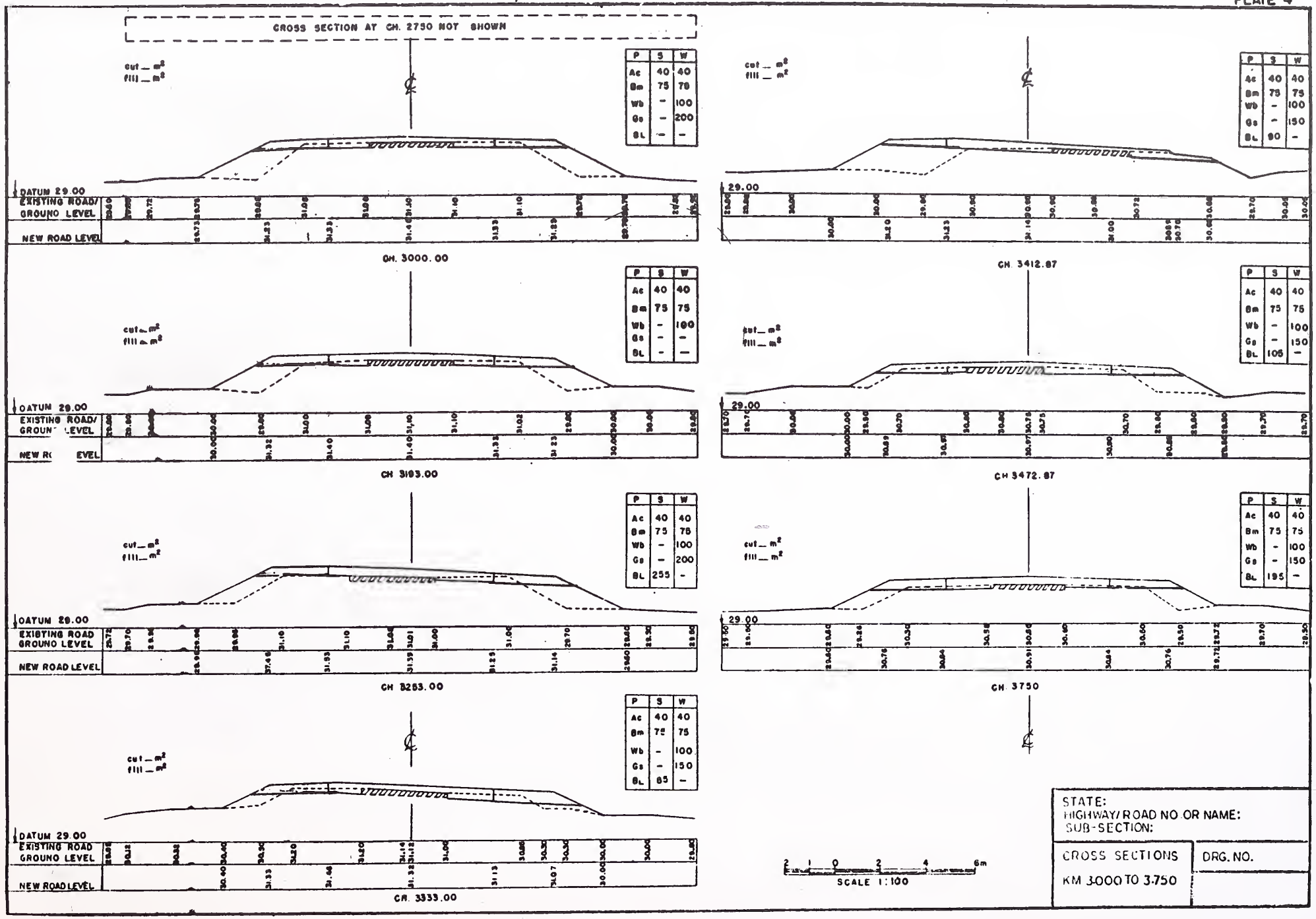
ASPHALTIC CONCRETE	Ac
BITUMINOUS MACADAM	Bm
BITUMINOUS LEVELLING COURSE	BL
WATER BOUND MACADAM (STONE METAL)	Wb
GRAVEL	Gs
EXISTING ROAD	- - - -
PROPOSED ROAD	———
EXISTING PAVEMENT	/////
PAVEMENT COMPOSITION	——— P
THICKNESS OF COURSE (mm) FOR STRENGTHENING	——— S
THICKNESS OF COURSE (mm) FOR WIDENING / NEW CONSTRUCTION	——— W

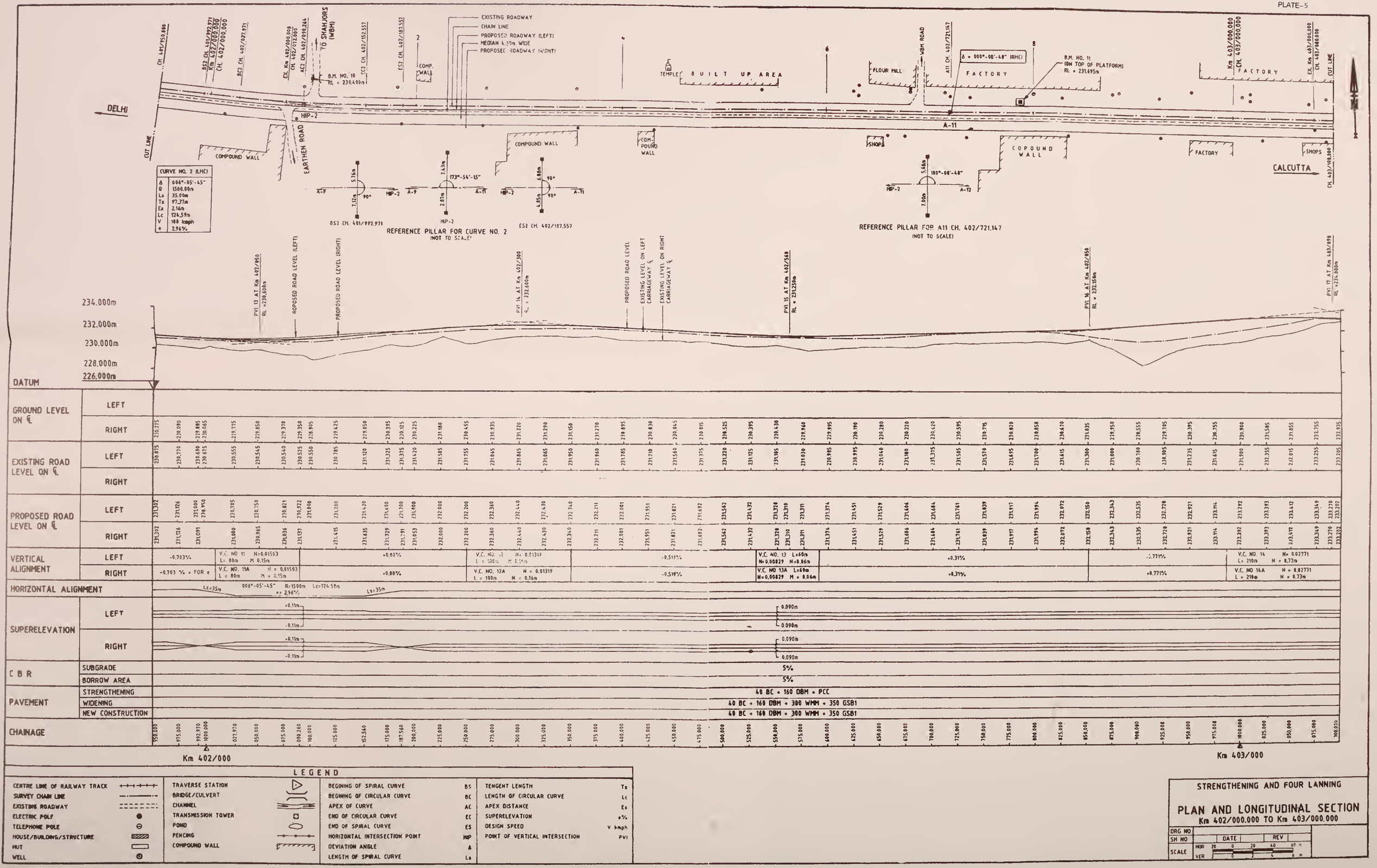
NOTES:-

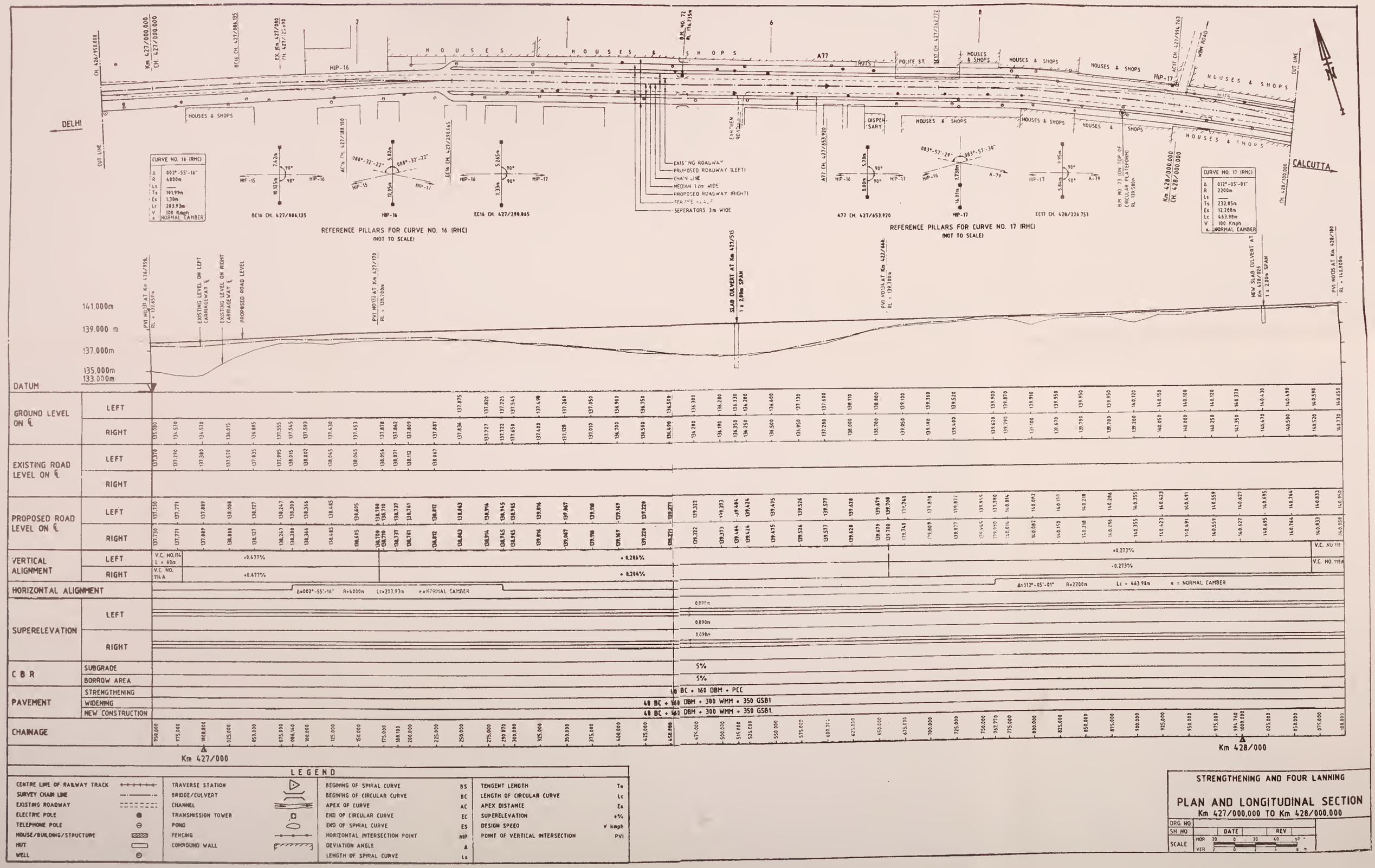
1. ALL DIMENSIONS UNLESS OTHERWIS… SPECIFIED ARE IN METRES
2. THICKNESS OF PAVEMENT COURSES IS NOT TO SCALE
3. IN CASE THE SUB-BASE LAYER IS TO ACT AS A DRAINAGE LAYER THE SAME SHALL BE EXTENDED UPTO THE SLOPE OF EMBANKMENT.

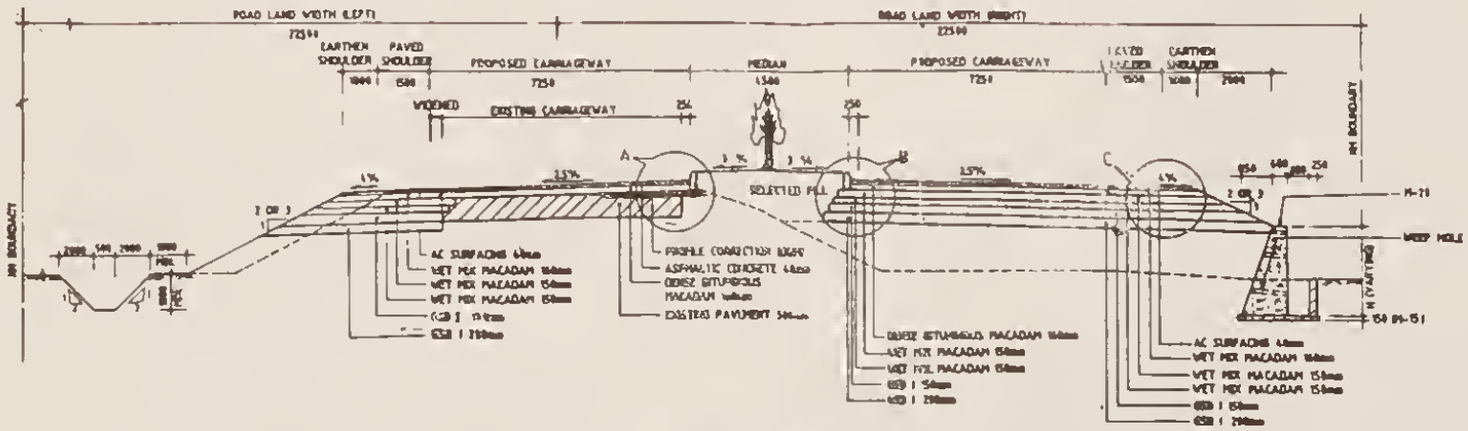
TYPICAL CROSS-SECTIONS

PLATE 4

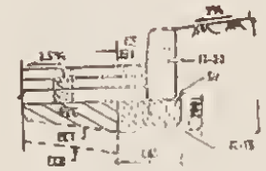

CROSS SECTION AT CH. 2750 NOT SHOWN
cut _ m²
fill _ m²
P S W
Ac 40 40
Bm 75 75
Wb - 100
Gs - 200
BL - -
DATUM 29.00
EXISTING ROAD/ GROUND LEVEL
NEW ROAD LEVEL
CH. 3000.00
Ac 40 40
Bm 75 75
Wb - 100
Gs - 150
BL 90 -
29.00
CH. 3412.87
Ac 40 40
Bm 75 75
Wb - 100
Gs - -
BL - -
CH 3193.00
Ac 40 40
Bm 75 75
Wb - 100
Gs - 150
BL 108 -
CH 3472.87
Ac 40 40
Bm 75 75
Wb - 100
Gs - 200
BL 255 -
CH 3253.00
Ac 40 40
Bm 75 75
Wb - 100
Gs - 150
BL 195 -
CH. 3750
Ac 40 40
Bm 75 75
Wb - 100
Gs - 150
BL 85 -
CH. 3333.00
SCALE 1:100
STATE:
HIGHWAY/ROAD NO OR NAME:
SUB-SECTION:
CROSS SECTIONS
KM 3.000 TO 3.750
DRG. NO.


DELHI
CALCUTTA
CUT LINE
EXISTING ROADWAY
CHAIN LINE
PROPOSED ROADWAY (LEFT)
MEDIAN 4.50m WIDE
PROPOSED ROADWAY (RIGHT)
TO SHAHJOORS (WBM)
EARTHEN ROAD
COMPOUND WALL
COMP. WALL
TEMPLE
BUILT UP AREA
FLOUR MILL
WBM ROAD
FACTORY
SHOPS
B.M. NO. 10 RL = 230.400m
B.M. NO. 11 (ON TOP OF PLATFORM) RL = 231.495m
Δ = 000°-00'-48" (RHC)
A-11
HIP-2
CURVE NO. 2 (LHC)
Δ 006°-05'-45"
R 1500.00m
Ls 35.00m
Ts 97.37m
Es 2.14m
Lc 124.59m
V 100 kmph
e 2.96%
REFERENCE PILLAR FOR CURVE NO. 2 (NOT TO SCALE)
REFERENCE PILLAR FOR A11 CH. 402/721.147 (NOT TO SCALE)
PROPOSED ROAD LEVEL
EXISTING LEVEL ON LEFT CARRIAGEWAY ℄
EXISTING LEVEL ON RIGHT CARRIAGEWAY ℄
234.000m
232.000m
230.000m
228.000m
226.000m
DATUM
GROUND LEVEL ON ℄
EXISTING ROAD LEVEL ON ℄
PROPOSED ROAD LEVEL ON ℄
VERTICAL ALIGNMENT
HORIZONTAL ALIGNMENT
SUPERELEVATION
C B R
SUBGRADE
BORROW AREA
PAVEMENT
STRENGTHENING
WIDENING
NEW CONSTRUCTION
40 BC + 160 DBM + PCC
40 BC + 160 DBM + 300 WMM + 350 GSB1
CHAINAGE
Km 402/000
Km 403/000
LEGEND
CENTRE LINE OF RAILWAY TRACK
SURVEY CHAIN LINE
EXISTING ROADWAY
ELECTRIC POLE
TELEPHONE POLE
HOUSE/BUILDING/STRUCTURE
HUT
WELL
TRAVERSE STATION
BRIDGE/CULVERT
CHANNEL
TRANSMISSION TOWER
POND
FENCING
COMPOUND WALL
BEGINNING OF SPIRAL CURVE BS
BEGINNING OF CIRCULAR CURVE BC
APEX OF CURVE AC
END OF CIRCULAR CURVE EC
END OF SPIRAL CURVE ES
HORIZONTAL INTERSECTION POINT HIP
DEVIATION ANGLE Δ
LENGTH OF SPIRAL CURVE Ls
TENGENT LENGTH Ts
LENGTH OF CIRCULAR CURVE Lc
APEX DISTANCE Es
SUPERELEVATION e%
DESIGN SPEED V kmph
POINT OF VERTICAL INTERSECTION PVI
STRENGTHENING AND FOUR LANNING
PLAN AND LONGITUDINAL SECTION
Km 402/000.000 TO Km 403/000.000
DRG NO
SH NO
DATE
REV
SCALE
HOR
VER

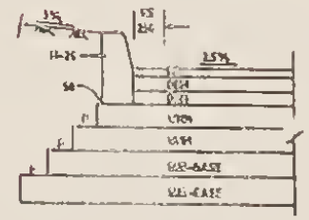

DELHI
CALCUTTA
CUT LINE
HOUSES & SHOPS
HUTS
POLICE ST.
DISPENSARY
A77
HIP-16
HIP-17
Km 427/000.000
CH. 427/000.000
Km 428/000.000
CH. 428/000.000
CURVE NO. 16 (RHC)
Δ 002°-55'-16"
R 4000m
Ls —
Ts 101.99m
Es 1.30m
Lc 203.93m
V 100 Kmph
e NORMAL CAMBER
CURVE NO. 17 (RHC)
Δ 012°-05'-01"
R 2200m
Ls —
Ts 232.05m
Es 12.28m
Lc 463.98m
V 100 Kmph
e NORMAL CAMBER
EXISTING ROADWAY
PROPOSED ROADWAY (LEFT)
CHAIN LINE
MEDIAN 12m WIDE
PROPOSED ROADWAY (RIGHT)
SEPERATORS 3m WIDE
REFERENCE PILLARS FOR CURVE NO. 16 (RHC)
(NOT TO SCALE)
REFERENCE PILLARS FOR CURVE NO. 17 (RHC)
(NOT TO SCALE)
SLAB CULVERT AT Km 427/515
1 x 2.00m SPAN
NEW SLAB CULVERT AT Km 428/026
1 x 2.00m SPAN
141.000m
139.000 m
137.000m
135.000m
133.000m
DATUM
GROUND LEVEL ON ℄
EXISTING ROAD LEVEL ON ℄
PROPOSED ROAD LEVEL ON ℄
VERTICAL ALIGNMENT
HORIZONTAL ALIGNMENT
SUPERELEVATION
C B R
SUBGRADE
BORROW AREA
PAVEMENT
STRENGTHENING
WIDENING
NEW CONSTRUCTION
40 BC + 160 DBM + PCC
40 BC + 160 DBM + 300 WMM + 350 GSB1
CHAINAGE
Km 427/000
Km 428/000
LEGEND
CENTRE LINE OF RAILWAY TRACK
SURVEY CHAIN LINE
EXISTING ROADWAY
ELECTRIC POLE
TELEPHONE POLE
HOUSE/BUILDING/STRUCTURE
HUT
WELL
TRAVERSE STATION
BRIDGE/CULVERT
CHANNEL
TRANSMISSION TOWER
POND
FENCING
COMPOUND WALL
BEGINNING OF SPIRAL CURVE BS
BEGINNING OF CIRCULAR CURVE BC
APEX OF CURVE AC
END OF CIRCULAR CURVE EC
END OF SPIRAL CURVE ES
HORIZONTAL INTERSECTION POINT HIP
DEVIATION ANGLE Δ
LENGTH OF SPIRAL CURVE Ls
TENGENT LENGTH Ts
LENGTH OF CIRCULAR CURVE Lc
APEX DISTANCE Es
SUPERELEVATION e%
DESIGN SPEED V kmph
POINT OF VERTICAL INTERSECTION PVI
STRENGTHENING AND FOUR LANNING
PLAN AND LONGITUDINAL SECTION
Km 427/000.000 TO Km 428/000.000
DRG NO
SH NO
DATE
REV
SCALE
HOR
VER



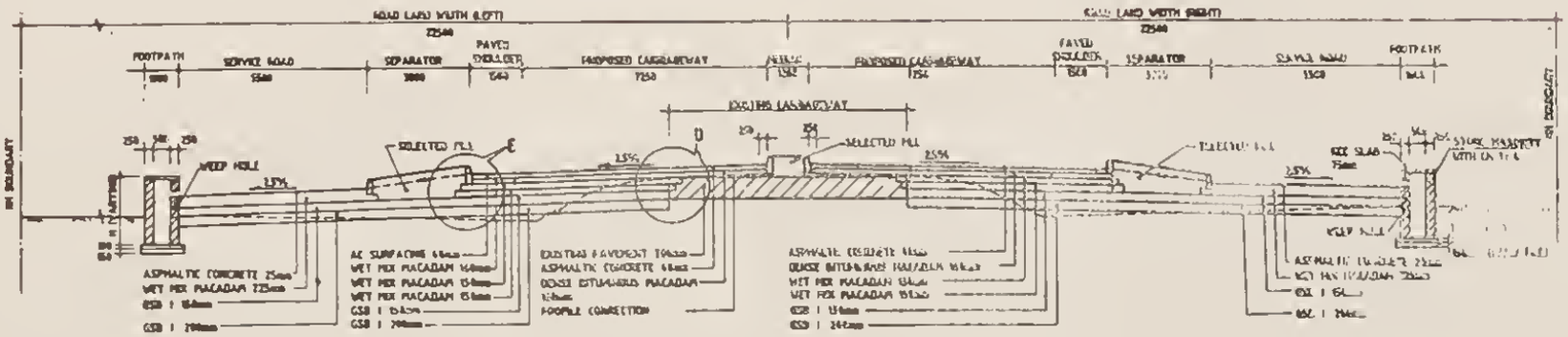
TYPICAL CROSS-SECTION IN STRAIGHT REACH
(ONE SIDE WIDENING)



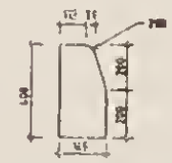
DETAIL OF A
(NOT TO SCALE)



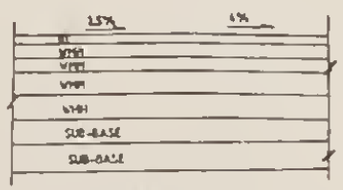
DETAIL OF B
(NOT TO SCALE)



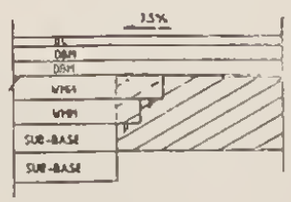
TYPICAL CROSS-SECTION WITH SERVICE ROAD IN BUILT UP AREA
(SYMMETRICAL WIDENING)



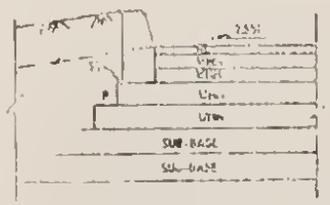
KERB
(NOT TO SCALE)



DETAIL OF C
(NOT TO SCALE)



DETAIL OF D
(NOT TO SCALE)



DETAIL OF E
(NOT TO SCALE)

NOTES:-

1. ALL DIMENSIONS [illegible] UNLESS OTHERWISE SPECIFIED.
2. GRANULAR SUB-BASE [illegible]
3. SIDE SLOPES OF EMBANKMENT [illegible] FOR HEIGHT UP TO [illegible] FOR HEIGHTS OF [illegible]
4. IF HEIGHT OF EMBANKMENT [illegible] AND HORIZONTAL CURVE RADIUS [illegible] PROTECTED RAILING WITH WOODEN POST [illegible] DRIVEN NO BITES/AW/CW/WS-AL.
5. KERB SHALL REST ON [illegible] CONSTRUCTED BEFORE LAYING [illegible]
6. P – THICKNESS OF [illegible]
7. ECT – EXISTING CRUST FM
   EGB – EXISTING CRUST BOTTOM
   PCC – PROFILE CORRECTION COURSE
8. KS – KERB SHIFTING OF [illegible] TO [illegible] WIDE CARRIAGEWAY.

LEGEND

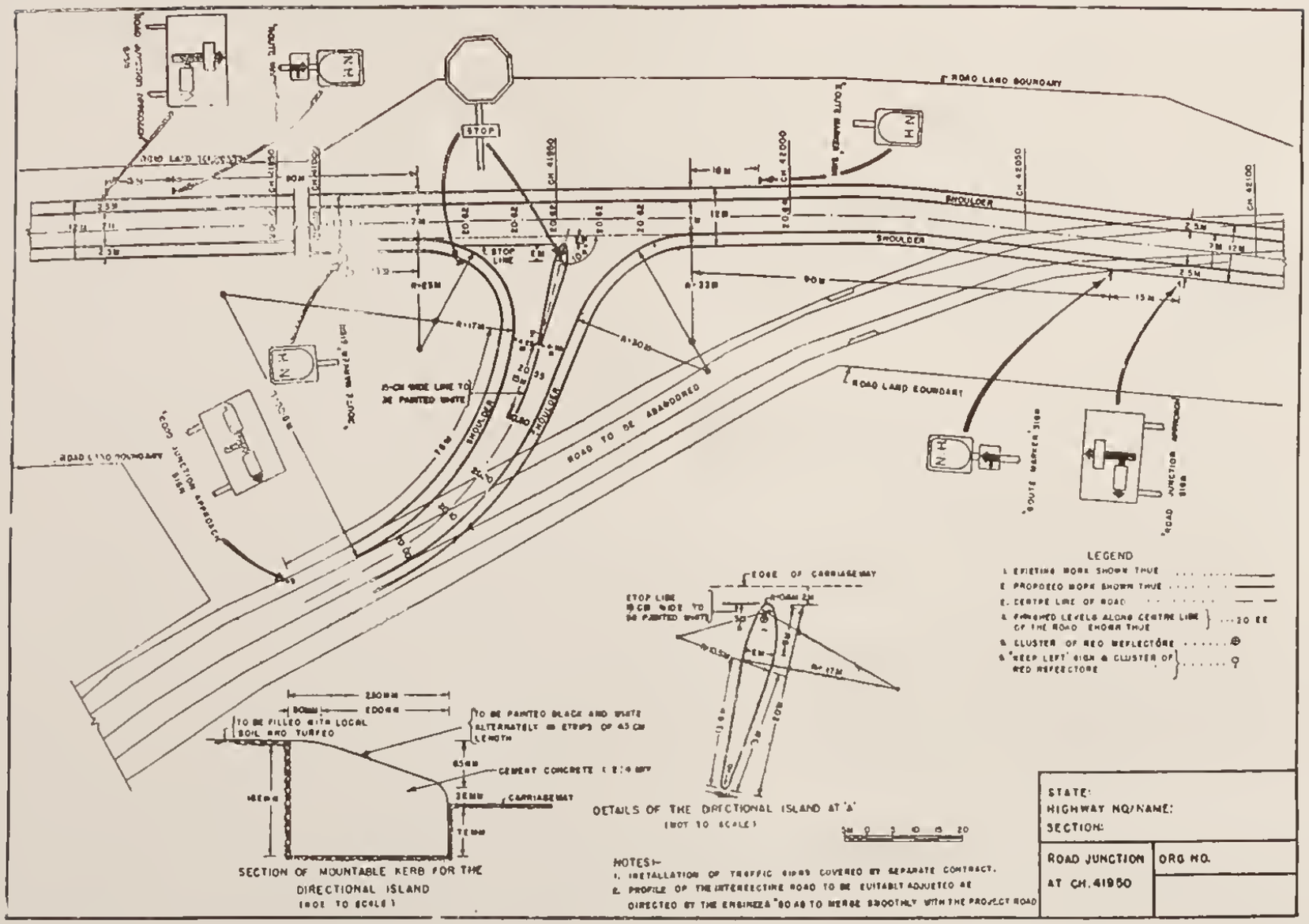
CENTRE LINE OF CARRIAGEWAY TRACK	TRAVERSE STATION	BEGINNING OF SPIRAL CURVE	TANGENT LENGTH
SURVEY LINE	BRIDGE/CULVERT	BEGINNING OF CIRCULAR CURVE	LENGTH OF CIRCULAR CURVE
EXISTING RAILWAY	CHAINAGE	APEX OF CURVE	APEX DISTANCE
ELECTRIC POLE	TRANSMISSION TOWER	END OF CIRCULAR CURVE	SUPERELEVATION
TELEPHONE POLE	POND	END OF SPIRAL CURVE	DESIGN SPEED
POWER/TELEGRAPH STRUCTURE	POSTLIGHT	HORIZONTAL INTERSECTION POINT	CURVE IN VERTICAL INTERSECTION
HUT	COMPOUND WALL	DEFLECTION ANGLE	
WELL		LENGTH OF SPIRAL CURVE	

TYPICAL DETAILED CROSS-SECTION

STRENGTHENING AND FOUR LANNING

TYPICAL CROSS-SECTION WITH FLEXIBLE PAVEMENT

SCALE


ROAD LAND BOUNDARY
STOP
SHOULDER
STOP LINE
ROAD TO BE ABANDONED
LEGEND
EDGE OF CARRIAGEWAY
DETAILS OF THE DIRECTIONAL ISLAND AT 'A'
(NOT TO SCALE)
SECTION OF MOUNTABLE KERB FOR THE DIRECTIONAL ISLAND
(NOT TO SCALE)
CARRIAGEWAY
NOTES:-
STATE:
HIGHWAY NO/NAME:
SECTION:
ROAD JUNCTION AT CH. 41950
ORG NO.